Introducing New Profit Streams for Grain Sorghum
Milling Characteristics and Inclusion Considerations for Use in Pet Foods

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Summary
The overall goal of this project is to understand sorghum component characteristics during milling, processing into pet food, and their utility from an animal feeding perspective. Sorghum is an important crop to the United States with a large quantity fed to cattle and used to produce ethanol, but little finds its way into the growing pet food market. The pet food market is a vibrant component of the agriculture and feed landscape, with an estimated $21 billion in annualized sales in the U.S. alone. This would translate into approximately 9.5 MMT, approximately 40 percent of that would come from grains produced in the U.S. The pet food industry is marketing driven and in a constant search for new and alternative ingredients to promote their attributes in order to expand and differentiate products. Discovery of "new" ingredients is vital and defensible claims are highly valued and rewarded in this high-margin market. Whole sorghum is not new to this market but sorghum components could be a significant new and exciting ingredient(s) entrant if there was a sufficient amount of supporting information and instruction on sorghum's use. This proposal addresses the critical issue of increasing usage of sorghum in pet foods. The proposal includes three phases to characterize sorghum suitability as a raw ingredient in pet foods. The milling phase will determine quality and nutritional characteristics of sorghum fractions. The pet food production phase will incorporate results from the first phase into actual pet foods, while the third phase will manage end user related issues such as palatability and digestibility issues. The outcome of this project will provide new information about value-added product streams and applications for grain sorghum in the growing pet food industry.

The specific objectives of this project are:

1. To evaluate dry and standard milling processes on yield characteristics of sorghum fractions (flour, bran, germ) as value-added ingredients in pet foods.
2. To determine the impact of various component parts (flour, bran, germ) from sorghum on processing characteristics in standard pet foods.
3. To determine the effects of varying levels of sorghum flour, bran, germ content in a standardized pet food on indices of animal utilization, palatability, and pet owner acceptance.

Background and Relevance

Sorghum origin: Sorghum or milo, as it is sometimes called, originates from northeast Africa and Asia and is a close cousin to millet and (sugar) cane. It is a perennial grass commonly grown as an annual grain crop in more 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 fifth most important grain (around 54 MMT produced annually) with the U.S., India and Nigeria being the top three producing countries (FAOSTAT3, 2011). Despite this global reach and supply-side sustainability, the value of sorghum is not widely recognized by pet food marketing representatives.

Nutrient composition and utilization: From a nutrition standpoint, sorghum should be a good fit for pet food. The nutrient profile compares favorably to corn, with starch being the largest portion around 75 percent. Most of the starch is in the form of amylopectin (70-80 percent). The protein content is slightly higher than corn, which is at or above nine percent, with lysine and threonine being the first and second limiting amino acids. The fat content of sorghum is slightly lower at approximately three percent than that of corn, which is in part responsible for its lower metabolizable energy. The essential fatty acid, (for dogs and cats) linoleic acid (C18:2n6), comprises greater than half the total fatty acids and another third comes from oleic acid (C18:1n9; not an essential fatty acid for pets). Less than three percent of the total fatty acids come from the omega-3 linolenic acid (C18:3n3). The fiber fraction (crude fiber 2-3 percent) is primarily insoluble with measurable amounts of lignin (primarily ferulic and p-coumaric acid) in the seed coat. The mineral (ash 1-2 percent) and vitamin content are comparable to many other cereal grains.

Sorghum for dogs and cats: Several researchers have evaluated the use of whole sorghum in extruded dog and cat diets. In dogs, the extent of starch digestibility was reported to be similar to
that of other grains like corn or rice (Carciofi et al., 2004; Twomey et al., 2002; Murray et al., 1999). The in vitro work of Murray et al. (2001) suggested the rate of starch digestion might be slower due to the composition of the sorghum starch. Corroborating evidence of this, albeit indirect, has been reported with intravenous glucose tolerance tests. In this case, studies with dogs (Carciofi et al., 2004; Sunvold and Bouchard, 1998) and cats (Bouchard and Sunvold, 2000) fed extruded sorghum-containing diets had lower concentrations of glucose, time to peak glucose was longer, and the insulin response curve was dampened after a test meal containing sorghum when compared to diets containing rice or corn. In essence, sorghum demonstrated a lower glycemic index (GI). A low GI claim has become a very popular attribute for pet food marketers.

**Condensed tannins:** 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. However, despite what appears to be a generally good report card, there are very few pet food companies that use or promote sorghum as part of their foods. The reason for this lies within sorghum’s limited name recognition by consumers and a reputation in some feed sectors for being slightly lower value relative to corn. This reputation has been earned from some less than stellar feeding studies from the past in which digestibility and performance of livestock compared unfavorably to corn. This contradiction for livestock feed results with the results noted above for dog and cat food rests at the seed surface. As is commonly recognized, for the commercial trade, sorghum is classified into several groups based primarily on the seed coat (pericarp) color. In its simplest interpretation, sorghums are either tannin (brown), white, or a couple of incremental combinations of the two (Rooney and Serna-Saldívar, 2000). The tannins, though, not actually tannic acid like the name would suggest, are more accurately proanthocyanidins or for simplicity “condensed tannins.” All sorghums contain these condensed tannins – some more than others. These condensed tannins are a cauldron of different polyphenolic compounds produced as secondary metabolites by the plant. These compounds 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”). However, there is an off-setting drawback as some of the condensed tannin sub-fractions precipitate proteins, inhibit digestive enzymes (amylase inhibitor, trypsin inhibitor) and bind (chelate) trace minerals. Because of this, it has been common to consider condensed tannins as anti-nutritional factors to avoid, especially the tannin (brown) sorghums. In addition, tannins have been related to astringent mouthfeel and bitter taste in foods manufactured from sorghum (Brannan et al., 2001). It has been found that astringency and bitterness in sorghum foods develop at different speed and that the astringent sensation lasts longer than bitterness does (Kobue-Lekalake et al., 2012). This aspect may influence animal acceptability of feeds manufactured with sorghum flour and will be studied in this proposal via human sensory analysis and palatability testing by pets. The upside is that not all condensed tannins are the same. Recent research has shown sorghum proanthocynadins may impart health benefits. For example, the hydroxycinnamic acid and flavonoid fractions of these condensed tannins have anti-tumor (esophageal, colon), antiviral (HIV), melanogenic and satiety effects. The flavonoid pigments (blues, purples, and reds) are process stable natural food colorings. Furthermore, the antioxidant properties of many of the phenolic compounds impart to sorghum 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). Since condensed tannins are not a single compound, but rather a host of many, there is an opportunity to identify and select sorghums for beneficial properties at the expense of the anti-nutritional properties and (or) to create sub-fractions that concentrate certain elements and provide added value. It is this latter approach that we propose to evaluate.

**Sorghum potential:** Thermal processing, such as extrusion and steam flaking, and chemical treatment with alkali can improve performance of high tannin sorghums. Currently, low tannin varieties (white, red and yellow sorghums) are more common and can be used effectively in dog and cat diets as a key ingredient in mainstream conventional diets as well as a vital part of a diabetic and weight control regime. On the horizon, there may be opportunities to exploit the antioxidant and nutraceutical benefit of sorghum in pet food once the condensed tannins story is better clarified. If this comes to pass, sorghum might emerge as the next “hot” new novel carb. Our recent
research has shown that consumers are willing to accept foods including sorghum better if these foods include some other characteristics as well, such as grown in the U.S., high in antioxidant content, or most importantly, sensory characteristics (Vazquez-Araujo et al., 2012). This is why our proposal includes an emphasis on palatability and consumer studies in addition to all of the characteristics of sorghum milling and processing. It is important to note that most of the key attributes of sorghum identified above are for component parts of the seed whereas all the research reported thus far for pets has been done with the whole seed. In other words, the missing component to making a value-added sorghum utilization improvement is to process the seed into components parts, which will improve its prospects for inclusion into pet foods and other specialty feeds.

**Justification and Relevance to Target Audience**

This project will help achieve the United Sorghum Checkoff Program mission of enhancing the sorghum industry by studying sorghum grain fractions (new value-added product streams) in pet foods. The pet foods manufactured with sorghum grain fractions will be further studied for their nutrient content, feeding characteristics and palatability. The results from this project will be disseminated to target audiences through scientific and non-scientific publications. The increased public knowledge will eventually increase demand for sorghum and will lead to increased production quantities.

Sorghum is an important crop to the United States. A large quantity of this crop is fed to cattle and used to produce ethanol, but little finds its way into the growing pet food market. The pet food market is a vibrant component of the agriculture and feed landscape with an estimated $21 billion in annualized sales in the U.S. This would translate into approximately 9.5 MMT, approximately 40 percent of that would come from grains produced in the U.S. The pet food industry is very marketing driven and in a constant search for new and alternative ingredients for which to promote in order to expand and differentiate products. It is a very competitive and market-driven consumer packaged goods industry. Discovery of “new” ingredients is vital and defensible claims are highly valued and rewarded in this high-margin market. Whole sorghum is not new to this market, but sorghum components could be a significant new and exciting ingredient(s) entrant with a small amount of supporting information and instruction on their use. The outcome of this project will provide new information about value added product streams and applications for grain sorghum in the growing pet food industry.

**Goals and Objectives**

The overall goal of this project is to understand sorghum component characteristics during milling and processing into pet food and their utility from an animal feeding perspective.

The following are the objectives of this study:

1. To evaluate dry and standard milling processes on yield characteristics of sorghum fractions (flour, bran, germ) as value-added ingredients in pet foods.
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**Methods/Activities**

During year one of this study will use sorghum varieties which are commercially available and locally grown. Before milling, we will measure all relevant analytical information such as moisture, fat, protein and ash for each cultivar being studied. In addition to these chemical tests, we will measure physical properties such as test weight and kernel hardness using the Single Kernel Characterization System (SKCS). Pilot scale milling will be done in the Hal Ross Flour Mill, where the sorghum will be decorticated then milled using a conventional roller milling process. The material removed during decortication (mixed bran and germ) will be further processed by air classification to separate bran from germ. In addition to these three milling fractions (bran, germ and flour), we will also mill a whole meal version to be included in our tests of sorghum in pet food.
diets. Yield for each fraction and its proximate composition, fiber by various accepted methods, starch composition (amylose, amylopectin), and key phenolic constituents will also be measured. From this information pet diets will be formulated according to composition mirroring a standard dog food offering in the market today. These experimental diets will be produced by typical production techniques (e.g. extrusion, baking, etc) and their characteristics will be compared to formulas utilizing whole sorghum and (or) rice as a control. Finally, we will determine the chemical constituents, flavor profiles using descriptive sensory analysis (Di Donfrancesco et al., 2012), and main aromatic compounds (Koppel et al., 2013) in these finished feeds. In addition, the dog foods will be subjected to a consumer acceptance study to determine if aroma or appearance of dog foods manufactured with sorghum in relation to dog foods manufactured with a control grain such as rice have an effect on consumer opinion. Experimental dog food will be subjected to a standard two-bowl dog palatability test. Information collected from the descriptive sensory analysis, aromatic compounds, and consumer acceptance test will be combined with the palatability tests results.

During year two, the project aims to evaluate the dog food produced via in vitro two-stage models for canine small intestinal and colonic and fecal digestibility according to Sunvold et al. (1995). Experimental dog foods will be fed to weanling pigs (as a model for dogs) in a standard 14-d growth assay. Feed and fecal samples will be collected and analyzed for nutrient digestibility. Blood plasma will be collected through jugular puncture. Total phenol content in plasma, feed and fecal samples will be measured using methods such as HPLC, Folin-Ciocalteu reaction or Trolox equivalent antioxidant capacity.

**Education/Outreach**

The expected outcome of this project is a description of new value added product streams from grain sorghum with demonstrated functional and nutritional value which will improve the marketability (domestic and international) of sorghum grain into a previously under-supported industry – pet food. There is an ever increasing pressure on sorghum acreage in the U.S. from corn and/or other alternative energy sources. If sorghum is to remain competitive as a commercially produced cereal grain, complete knowledge of its nutritional value and processing characteristics is necessary. We anticipate that the results from our experiments will define any nutritional and processing benefits from further processing sorghum and begin to provide evidence on dosage and targeted response. We anticipate that our data will be used extensively to meet the information needs of decision makers in the pet food industry and generate new interest by nutritionist in the pet and human alternative health industries. To ensure use of our data, the information will be disseminated through peer-reviewed publications, popular press magazines (of which the PI is a regular columnist), at scientific meetings of regional, national, and international levels, and at producer/feed manufacturer seminars in Europe, Asia, Africa, and throughout the Americas.
References


