FEED VALUE BENEFITS OF SORGHUM FOR POULTRY

SORGHUM THE SMART CHOICE

INTRODUCTION

All types of poultry require their diet contain a large percentage of cereal grains to provide protein and energy in their ration. The primary cereal grains used in poultry rations around the world include corn, wheat, barley, rice and sorghum. Grain sorghum is produced in much smaller quantities than corn in the U.S. and is used in lesser quantities as an animal feed since poultry are not grown in high sorghum production areas. However, sorghum is still the second most used cereal grain for commercial growers of broilers, turkeys and egg layers in regions where both are grown in the U.S.

New varieties of grain sorghum are an excellent source of protein and energy for broilers, egg layers, turkeys and waterfowl. Because sorghum is often grown in areas where water resources are limited, sorghum production requires fewer environmental resources. Thus, some users of grain sorghum consider it to have less environmental impact compared to grains requiring larger allotments of moisture and fertilizer. When competitively priced, grain sorghum can be used at up to 70 percent in a broiler and layer rations and 55 percent in turkey rations replacing all corn.

The nutrient profile of sorghum is complementary to protein sources typically formulated in poultry rations anywhere in the world and is very similar to corn (maize)

when used in this combination. Amino acid digestibility compares favorably with corn, especially when considering newer sorghum varieties that are produced in the U.S. today.

As our understanding of feed processing and the nutrient profile of grain sorghum increases, greater opportunities for expanded grain sorghum use exist to capitalize on its full potential in poultry diets. Grain sorghum provides an excellent opportunity for poultry producers or feed suppliers to lower feed costs.

When processing grain sorghum for feed manufacturing, new research is showing that sorghum has similar processing requirements when compared to corn. Sorghum particle size is more important for feed manufacturing than nutrient uptake by poultry. Over processing of grain sorghum could cause chemical cross linking and reduce nutrient availability. Some studies have even demonstrated that whole sorghum particles can be added to poultry rations without loss of performance.

Sorghum varieties continue to be improved by plant breeders. Sorghum planted in the U.S. does not contain tannins, which interfere with metabolism and absorption of nutrients. Because tannins have been reduced in sorghum, this has greatly improved nutrient digestibility for poultry.

HISTORICAL LITERATURE VALUES

In years past, many poultry nutritionists would typically discount the nutritional value of grain sorghum compared to corn or wheat. The nutritional value of sorghum was assumed to be 85 to 90 percent of the total feeding value of corn. For sorghum to replace corn in a lower-cost feed formulation, this meant that sorghum had to trade at prices much lower than corn before it would be included in the formulation. Today's sorghum varieties compare more favorable to corn in lower-cost feed formulations.

Old varieties of grain sorghum contained relatively high amounts of an anti-nutritional compound called tannin. The presence of tannin in poultry feeds is well known to suppress growth and performance of all types of poultry (Nyachoti et. al, 1996). Tannins bind to proteins and render them less available for metabolism. Although tannin reduces bird damage in fields of sorghum, poultry are birds, too, and are also affected by the anti-nutritional properties of tannin.

Over many decades of research this data, using sorghum varieties that contained various levels of tannin, was used to compile tables and other references for the feeding value of

sorghum compared to corn. Unfortunately, many nutritionists who do not have experience with sorghum continue to think of sorghum as a lesser grain compared to corn when, in fact, new varieties have been introduced that have high relative nutrient values. In many places, varieties of grain sorghum which contain significant quantities of tannin are still grown (Nyachoti et. al, 1997). However, U.S. varieties grown for animal feeding today are low tannin, or 99 percent free of tannin.

The classic reference used for poultry nutrition in the U.S. is The Nutrient Requirements of Poultry (NRC) which was last updated in 1994. The 4th edition of the NRC listed the proximate composition of grain sorghum at two levels of crude protein: 8 and 10 percent (Table 1). The proximate analysis of sorghum compared to corn indicates that the cereal grains are similar, with sorghum containing less oil and slightly more non-phytate phosphorus. The reduced oil results in slightly less energy value for poultry (as measured by TMEn). However, the average protein content of sorghum at the time of this publication indicates that sorghum contains more protein than corn.

GRAIN SORGHUM FEEDING VALUE

ENERGY VALUE

The fat content of grain sorghum and thus the energy value for poultry is slightly lower when compared to corn, but this difference is easily balanced in rations with other sources of energy such as animal byproduct meals or oils. Compared to corn, grain sorghum contains reduced quantities of yellow xanthophylls required for egg yolk pigmentation and skin coloration for broilers. In some cases where lighter meat products are preferred by the customer, sorghum may be used to reduce carcass pigmentation for marketing advantages. Where color is required for some products, such as egg yolks that require intense pigmentation, other sources of pigments like marigold oil, yeast products, synthetic compounds and even corn based DDGS are widely available and often can be included in rations on a least cost basis.

GRAIN SORGHUM FEEDING VALUE

TABLE 1. TYPICAL NUTRIENT COMPOSITION (AS-FED)[1]

	SORGHUM 8-10% PROTEIN	SORGHUM 8-10% PROTEIN	CORN
DRY MATTER, %	87	88	89
MEN (KCAL/KG)	3,288	3,212	3,350
TMEN (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	.82	2.20
CRUDE FIBER, %	2.3	2.3	2.2
TOTAL CALCIUM, %	.04	.04	.02
NON-PHYTATE PHOSPHOROUS, %	.30	.32	.28
PHOSPHOROUS, %			.08

[1]Values are derived from NRC. 1994. Nutrient Requirements of Poultry. 9th rev. ed. Natl. Acad. Press, Washington D.C.

GRAIN SORGHUM FEEDING VALUE

AMINO ACID PROFILE

The amino acid profile of sorghum compares favorably to corn and is complementary to the amino acid profile of soybean meal, which is often used as a protein source in poultry rations worldwide. Table 2 shows the amino acid composition of sorghum and corn. Although the lysine and methionine levels are slightly lower for grain sorghum compared to corn, the current availability of these amino acids in synthetic form for supplementation into least cost rations lessens the importance of slight differences in amino acid content.

Most poultry producers formulate feeds today using digestibility data. Table 3 shows the availability of amino acids for poultry in grain sorghum. The critical amino acids, lysine and methionine, are slightly lower in sorghum compared to corn. However, since this data is equalized based on protein content, the actual amino acid available for growth would be higher for sorghum compared to corn.

GRAIN SORGHUM FEEDING VALUE

TABLE 2. AMINO ACID COMPOSITION OF SORGHUM AND CORN (AS-FED)[1]

	SORGHUM 8-10% PROTEN	SORGHUM >10% PROTEIN	CORN
DRY MATTER, %	87.5	88.0	88.8
PROTEIN, %	9.1	11.0	8.5
ARGININE, %	.35	.35	.38
GLYCINE, %	.31	.32	.33
SERINE, %	.40	.45	.37
HISTIDINE, %	.22	.23	.23
ISOLEUCINE, %	.35	.43	.29
LEUCINE, %	1.14	1.37	1.00
METHIONINE, %	.16	.15	.18
CYSTINE, %	.17	.11	.18
PHENYLALANINE, %	.47	.52	.38
TYROSINE, %	.34	.17	.30
THREONINE, %	.29	.33	.29
TYPTOPHAN, %	.08	.09	.06
VALINE, %	.44	.54	.40

[1]Values are derived from NRC. 1994. Nutrient Requirements of Poultry. 9th rev. ed. Natl. Acad. Press, Washington, D.C.

GRAIN SORGHUM FEEDING VALUE

TABLE 3. TRUE DIGESTIBILITY COEFFECIENTS (%) FOR SELECTED AMINO ACIDS IN SORGHUM AND CORN[1]

	SORGHUM GRAIN (8.8%)	CORN GRAIN (8.8%)
LYSINE	78	81
METHIONINE	89	91
CYSTINE	83	85
ARGININE	74	89
VALINE	87	88
ISOLEUCINE	88	88
LEUCINE	94	93
HISTIDINE	87	94
PHENYLALINE	91	91
TRP	0.10	0.05

[1]Values are derived from NRC. 1994. Nutrient Requirements of Poultry. 9th rev. ed. Natl. Acad. Press, Washington, D.C.

Producers evaluating the choice of grain sorghum as an alternative cereal grain should carefully consider the source of nutritional values assigned to the nutrients from sorghum in their feed formulation software. For example, it is likely that some of the data resources used to compile the tables in the NRC (1994) are not accurate or precise today, because some data was based on tannin-containing varieties

that reduced nutrient value. U.S. grain sorghum exported today will have a much higher nutrient quality than in years past.

In the 1990s, researchers around the world began to work with grain sorghum varieties with reduced tannins, which improved nutrient digestibility. Tabled data collected since that time in countries that grow sorghum with reduced tannin is beginning to show that today's sorghum has more average nutritional values than previously determined. In fact, swine and poultry producers in the U.S. and Mexico who have extensive experience with sorghum feeding value grain sorghum as similar to corn when comparing relative nutrient values. These producers have often found economic situations where grain sorghum is favored to replace all or a portion of the cereal grain in their rations.

Nutritionists should evaluate grain sorghum based only on tannin-free sorghum varieties. Nearly all sorghum exports today are No. 2 grain sorghum, tannin-free and referred to as Type 1 sorghum. Research work should indicate the sorghum source.

GRAIN SORGHUM FEEDING VALUE

Research indicates new varieties of sorghum compare favorably to corn for most nutrient values. At Kansas State University, Kriegshauser, et al. (2006) compared the proximate analysis of several varieties of sorghum to corn and found that sorghum had higher values of protein as expected, while the energy or fat content of sorghum was slightly lower than that of corn (Table 4). The amino acid profile of the sorghums compared well to corn, although the average lysine content of sorghum tested to be .26 percent versus corn at .30 percent (Table 5).

TABLE 4. PROXIMATE ANALYSIS OF CORN AND SORGHUM HYBRID GRAIN SAMPLES (% DRY-MATTER BASIS)[1]

	CHEMICAL COMPOSITION					
	PROTEIN, %	FAT	FIBER	ASH	NFE	GROSS ENERGY, MCAL KG-1
SORGHUM (AVG OF 8 VARIETIES)	12.7	3.5	2.2	1.5	72.0	4528
CORN	10.2	3.8	2.2	1.4	73.8	4498

[1] Adapted from Kriegshauser et al. 2006.

TABLE 5. AVERAGE ESSENTIAL AMINO ACID CONTENT OF SORGHUM VARIETIES (% DRY-MATTER BASIS)[1]

ESSENTIAL AMINO ACIDS, %		
	SORGHUM	MAIZE
ARG	0.45	0.46
SER	0.84	0.79
HIS	0.29	0.30
ILE	0.44	0.32
LEU	1.54	1.17
LYS	0.26	0.30
CYS	0.46	0.47
TYR	0.98	0.77
THR	0.37	0.34
TRP	0.09	0.07
VAL	0.58	0.46
TOTAL	6.30	5.42

[1] Adapted from Kriegshauser et al. 2006.

The varieties of sorghum with improved nutrient composition also tested similar to corn for ME value in a broiler chick assay. The results of this work indicate that the nutritional value of sorghum is similar to corn in many nutrient values.

GRAIN SORGHUM FEEDING VALUE

CRUDE PROTEIN PROFILE

There are few digestibility studies comparing modern grain sorghum varieties side by side to other cereal grains. Huang et al., (2006) conducted a unique study to compare the apparent ileal digestibility of sorghum to corn using broilers, layers and mature leghorn roosters (Table 6). Crude protein digestibility of sorghum versus corn in all three classes of birds was similar between the grain sources.

However, the amino acids lysine and methionine were slightly more digestible in the corn samples. This work indicates that although protein content and digestibility may have improved recently, some of the amino acids still differ in digestibility. Similar work by Ravidran, et al. (2005) using ileal digestibility tests with broilers[2] found that the digestibility of crude protein was higher for sorghum compared to corn (99 vs. 81 percent). Digestibility of individual amino acids for corn and sorghum were similar for most essential amino acids.

Ileal digestibility of sorghum versus other cereal grains was conducted by Lemme, et al. (2004). When comparing crude protein

TABLE 6. APPARENT ILEAL DIGESTIBILITY (%) COEFFICIENTS OF CRUDE PROTEIN AND AMINO ACIDS IN SORGHUM AND CORN FOR BROILERS, LAYERS AND ROOSTERS[1]

	SORGHUM GRAIN (8.8%)	CORN GRAIN (8.8%)
LYSINE	78	81
METHIONINE	89	91
CYSTINE	83	85
ARGININE	74	89
VALINE	87	88
ISOLEUCINE	88	88
LEUCINE	94	93
HISTIDINE	87	94
PHENYLALINE	91	91
TRP	0.10	0.05

[1]Derived from Huang et al. 2006.

digestibility, sorghum was 86 percent versus corn at 90 percent, while the amino acid digestibility was only slightly lower for sorghum compared to corn. All of the preceding studies indicate that the amino acid digestibility for sorghum is similar in many studies, averaging 95-97 percent of corn values, much higher than older sources would indicate.

GRAIN SORGHUM FEEDING VALUE

ENZYMES

Most cereal grains and poultry benefit to some extent by the addition of enzymes that either increase nutrient availability or decrease the impact of anti-nutritional factors. For example, the use of glucanase enzymes to mitigate the negative effect of viscosity in wheat and barley-based diets. Sorghum, with possible anti-nutritional factors and difficult to digest protein layers would seem a good candidate for enzymes to improve feeding values.

Dominguez et al. (2009) studied the effect of adding a commercial mixture of pectinases, a-glucanases and hemicellulases to sorghum-soy feed rations for broilers and found that ileal amino acid digestibility increased three percent while the ME was increased by over 6 percent when used in rations that were marginal in nutrients. This demonstrates that enzymes can be used to get more nutrients from sorghum. Cadogan et al. (2005) tested phytase enzyme preps on sorghum-based diets and determined that the enzyme improved weight gain, amino acid digestibility, starch digestibility and performance of broilers. Limited studies do indicate that there are opportunities to use enzyme preparations to improve bird performance.

GRAIN SORGHUM FEEDING VALUE

Recent work to determine the feeding value of selected sorghum varieties by Nyanor et al. (2007) indicated that selection of grain sorghum for improved broiler performance could be achieved. The authors concluded that "Growth performance of broiler chicks was equally supported by corn or sorghum. Sorghum grain compares quite favorably with corn in terms of nutritional quality, and with the added advantage of tolerance to inclement weather, it could be economically incorporated into diets of nonruminants and ease the demand pressure on corn if favorably priced."

The consensus of nutritionists around the world is that sorghum is similar to corn in nutritional value for poultry provided that low tannin or tannin-free varieties are used. When sourced from the U.S., grain sorghum varieties can be used with confidence since the low tannin varieties are grown to maximize the value of sorghum in animal rations.

SORGHUM PROCESSING

The physical and chemical effects of heat, steam or moisture, pressure and grinding are known to influence digestibility of feed grains, including sorghum. Broiler and turkey feeds are fed in pelleted form, which results in improved weight gain and feed efficiency regardless of the type of feed grain used. Virtually 100 percent of meat bird rations in the U.S. are pelleted. Some researchers have indicated that it may be possible to process sorghum in such a way to improve the availability of nutrients to a greater extent than other grains. Thus particle size, processing time, pelleting method, etc. may all have an effect on the feeding value of corn.

The number of recent investigations that examine the effect of milling grain sorghum and making feed have been limited. Because more corn is used than sorghum in pelleted feeds, manufacturers have a large amount of experience with corn processing relative to sorghum processing in the poultry industry.

Feed manufacturers must consider the cost associated not only with nutritional changes, but also with the changes that may be necessary to handle and prepare a particular ingredient. Storage or identity preservation, grinding requirements and mill through put are just some

of the factors that must be considered when handling an additional grain. Saving money on basic nutrients that will only be lost during the manufacturing process is not a wise decision.

Experienced feed manufacturers will agree that feeds with added sorghum are more difficult to pellet. This is partly due to the slightly lowered energy value of feed that is sometimes balanced in the ration with additional oil or fat which is known to reduce pellet quality. Adjustments in retention time, temperatures, etc., may be necessary to reach desired pellet quality. However, manufacturers should be cautioned when extensively processing grain sorghum. Recent work from Selle et al. (2010) summarized data from other researchers that concludes sorghum could be vulnerable to moist heat that induces undesirable chemical cross linking in karafin proteins, which reduces nutritional quality.

It is not known if studies that implicated cross-links between some proteins and the starch in sorghum are affected by processing conditions (Rooney and Plfugfelder, 1986). Studies that attempted to restructure the sorghum proteins with methods like expansion showed that, although expansion greatly

improved the final pellet quality of sorghum-based rations, the increased pellet quality failed to result in better broiler performance, which is always demonstrated by pelleting. It could be that the excessive processing may have reduced any gains related to pelleting by lowering digestibility values of cross links that were induced by expansion. Studies to determine unique processing requirements of sorghum are needed.

Feed particle size may affect nutrient availability. However, broilers, layers and turkey choose feed based on size of the completed feed, not ground particle sizes. These birds do not masticate and reduce particle size orally, but instead rely on the gizzard to grind grain particles down to final size before the particles reach the small intestine. Therefore, birds should be able to handle quantities of large grain provided gut maturation has been reached. In fact studies indicate that birds grow well on sorghum that is not processed but left whole in the diet. If the price of sorghum is favorable for replacement of a portion of the wheat or corn fraction, the most cost effective way of adding a small quantity of grain sorghum is to simply add it to the diet in whole form.

SORGHUM PROCESSING

Whole sorghum was added to pelleted rations for broilers by Rodgers et al. (2009) who found that when compared to pellets made with ground sorghum, the birds fed pelleted rations with whole sorghum particles performed equally well. Another group has also presented work that indicates whole sorghum can be added to poultry rations without negatively affecting growth. Biggs and Parsons in 2009 fed rations with 10 and 20 percent whole sorghum and the birds at three weeks performed as well as those fed ground sorghum. The research work generally indicated that feeding whole grain as a portion of the diet would increase MEn and amino acid availability. However, the birds did tend to select the whole particles that could affect growth rate. So adding pelleting to the rations with whole grain may be the preferred method to prevent selection.

Other work has concluded that grinding sorghum into small particle size improves utilization. For broiler chicks, Duodo et. al., (2003) demonstrated that grinding sorghum to 500–700m did improve gain. Efficiency of gain also was improved more with fine grinding of sorghum than corn. Optimum particle sizes for F/G were 300 and 500m for hard and soft

sorghum, respectively. It is important to note that relative to corn, feeding values for chicks fed hard and soft sorghums at 900m were 92 percent, but at the optimum particle size for each grain relative feeding values for hard and soft sorghum were 99 percent that of corn. The data suggest that sorghums can equal corn in feeding value for broiler chicks when milled to their optimum particle size, and as pigs and chicks get older, optimum particle size increases.

Further research is needed to determine the particle size requirements of sorghum-based rations for optimizing nutrition when preparing grain sorghum for poultry rations. Since the cost of grinding sorghum to such small particles is likely to exceed the nutritional value gained, it is unlikely that highly ground feeds are economical for poultry. Feed manufacturers should choose particle sizes of sorghum based more on their required pellet quality rather than precision feeding small sorghum particles to poultry.

SORGHUM DDGS FEEDING VALUE

The majority of research conducted with DDGS has focused on corn-based DDGS. There has been a very limited number of research publications focusing on sorghum-based DDGS and all have examined the value of feeding DDGS to swine, beef cattle and dairy cattle. There are essentially no reliable research studies published at this time that have tested the value of feeding sorghum-based DDGS to any type of poultry.

Though little work has determined the value of sorghum-based DDGS for poultry, it is still likely to be a valuable feed ingredient for broilers, layers and turkeys. Corn-based DDGS have been used in large quantities by poultry growers for a decade, and there is no reason to indicate that sorghum won't be as successful. Because grain sorghum is well utilized by birds, sorghum DDGS should have similar strengths in feed formulas for birds. This has been the case for corn grain and corn-derived DDGS, as well. Because there are a few publications that show processing grain sorghum with heat and moisture could result in cross-linked nutrients that are more difficult for birds to metabolize, it would be crucial to determine nutrient bioavailability in sorghum DDGS before adding it to poultry feeds.

CHECKLIST FOR USING GRAIN SORGHUM IN POULTRY RATIONS

1. Be sure to utilize current tables for nutrient composition for contemporary varieties of grain sorghum.

2. Formulate sorghum rations based on nutrient digestibility rather than percent total nutrients.

3. Do not over process sorghum with heat, friction or moisture to reduce cross linking and loss of critical nutrients.

4. Select particle size for poultry based on required manufacturing constraints rather than bird requirements.

5. Use sorghum with confidence that low tannin varieties grown in the U.S. will not affect animal performance.

REFERENCES

Biggs, P. and C. M. Parsons. 2009. The effects whole grains on nutrient digestibility, growth performance and cecal short chained fatty acid concentrations in young chicks fed ground corn soybean meal diets. Poultry Sci. 88:1893-1905.

Boren, B. and R. D. Waniska. 1992. Sorghum seed color as an indicator of tannin content. J. Appl. Poultry Res. 1:117-121.

Cadogan, D. J., P. H. Selle, D. Creswell and G. Partridge. 2005. Phytate limits broiler performance and nutrient digestibility in sorghum based diets. Proc. of the 17th Australian Poultry Science Symposium, Sydney, New South Wales, Australia.

Cramer, K. R., K. J. Wilson, J. S. Moritz and R. S. Beyer. 2003. Effect of sorghum based diets subjected to various manufacturing procedures on broiler performance. J. Appl. Poultry Res. 12:404-410.

Dominguez, A. D., A. C. Cuevas, B. F. Martinez, C. L. Coello and A. E. Gonzalez. 2009. Effect of supplementing an enzyme mixture in

REFERENCES

sorghum+soybean meal diets on apparent ileal amino acid and protein digestibility, metabolize energy and productivity in broilers. Tecnica Pecuaria en Mexico. 47:15-29.

Duodu, K. G., J. R. N. Taylor, P. S. Belton and B. R. Hamaker. 2003. Factors affecting sorghum protein digestibility. J. Cereal Sci. 38:117-131.

Huang, K. H., X. Li, V. Ravindran and W. L. Bryden. 2006. Comparison of apparent ileal amino acid digestibility of feed ingredients measured with broilers, layers and roosters. Poultry Sci. 85:625-699.

Kriegshauser, T. D., M. R. Tuinstra and J. D. Hancock. 2006. Variation in nutritional value of sorghum hybrids with contrasting seed weight characteristics and comparisons with maize in broiler chicks. Crop Sci 46:695-699.

Lemme, A., V. Ravindran and W. L. Bryden. 2004. Ileal digestibility of amino acids in feed ingredients for broilers. World's Poultry Sci. J. 60:423-438.

Nyachoti, C. M., J. L. Atkinson and S. Leeosn.

1996. Response of broiler chicks fed a high-tannin sorghum diet. J. Appl. Poultry Res. 5:239-245.

Nyachoti, C. M., J. L. Atkinson and S. Leeson. 1997. Sorghum tannins: a review. World's Poultry Sci. J. 53:5-21.

Nyannor, E. K. D., S. A. Adedokun, B. R. Hamaker, G. Ejeta and O. Adeola. 2007. Nutritional evaluation of high-digestible sorghum for pigs and broiler chicks. J. Anim. Sci. 85:196-203.

Ravindran, V., L. I. Hew, G. Ravindran and W. L. Bryden. 2005. Apparent ileal digestibility of amino acids in dietary ingredients for broiler chickens. An. Sci. 81:85-87.

Rodgers, N., L. L. Mikkelsen, B. Svihus, H. Hetland and M. Choct. 2009. Effect of grain particle size and milling method on broiler performance and apparent metabolisable energy. Proc. of the 20th Australian Poultry Science Symposium, Sydney, New South Wales, Australia.

REFERENCES

Rooney, L. W. and R. L. Pflugfelder. 1986. Factors affecting starch digestibility with special emphasis on sorghum and corn. J. Anim. Sci. 63:1607-1623.

Selle, P. H., D. J. Cadogan, X. Li and W. L. Bryden. 2010. Implications of sorghum in broiler chicken nutrition. An. Feed Sci. and Tech. 156:57-74.

The Nutrient Requirements of Poultry. 1994. 9th rev. ed. Natl. Acad. Press, Washington, DC.

Waniska, R. D., L. F. Hugo and L. W. Rooney. 1992. Practical methods to determine the presence of tannins in sorghum. J. Appl. Poultry Res. 1:122-128.

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