EFFECTS OF ENDOSPERM TYPE ON NUTRITIONAL VALUE OF SORGHUM GRAIN FOR SWINE

By

KENT W. SMITH

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Major Professor

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INTRODUCTION

Sorghum grain has become an important feed grain in the Midwest, and particularly so in Kansas. In the Midwest, sorghum grain and corn are the principle carbohydrate sources for swine rations.

Sorghum grain can be grown in arid and wet climates thus, making production possible on marginal land. The development of better yielding, disease-resistant, and preditor-resistant varities and improved cultural practices has resulted in increased production in the United States. The increased acreage of sorghum grain in Kansas and the high plains region has helped expand the livestock industry in this area.

Limited information is available on the effects of endosperm type, endosperm texture, and starch type of sorghum grain on swine performance. The purpose of this study was to determine the effects of endosperm type on the nutritional value of sorghum grain for both growing and finishing swine.

REVIEW OF LITERATURE

Sorghum Grain History

The culture of sorghum grain began in eastern Africa in prehistoric times perhaps 5,000 to 7,000 years ago. The first recorded occurrence of sorghum is found in the Middle East around 700 B.C. It is believed that sorghum seed reached the western hemisphere by way of captive slaves during the 17th and 18th centuries. Significant amounts of sorghum grain were produced in the United States following the introduction of different seed stocks from Egypt, South Africa, India and South America in the period from 1874 to 1890. Other important introductions were pink kafir from South Africa about 1905, and feterita and hegari from Sudan in 1906 and 1908, respectively (Martin, 1970).

Sorghum Grain Production

Sorghum grain was produced on approximately 130 million acres in 1966. It ranks fifth in acreage of the crops of the world, being exceeded by wheat, rice, maize, and barley. Sorghum is grown on all 6 continents in areas where the average summer temperature exceeds 20°C and the frost-free season is 125 days or more. The worlds total production was about 56 million metric tons, or 2.2 billion bushels in 1966. The United States and Asia each produced about one third and Africa slightly less than one fourth of this total. More than 70% of the production was in Latin-America. Europe and Oceania together produced a little over 1% of the crop. The leading producing countries were the United States, Mainland China, India, Nigeria, Mexico, Argentina, Sudan, and Egypt. The average yield per acre for the world was about 17 bushels. The yields in Asia and Africa are somewhat below this average. The United States, Egypt, France and Mexico all had average yields higher than that of the world average (Martin, 1970).

Sorghum grain is a relatively new crop and expanding in importance in the United States with more than 700 million bushels of sorghum grain produced in 1967. Sorghum grain is the third largest cereal crop in the U.S. The major producing states are Texas, Kansas, Nebraska, Oklahoma, Missouri, New Mexico, Arizona, South Dakota, Colorado and California. In Texas, sorghum is the number one grain crop.

Production in the United States is expanding very rapidly. In 1930, 49 million bushels was harvested from 3.4 million acres; in 1965, 66 million bushels from 13.3 million acres was produced. This rapid expansion of sorghum grain can be attributed to many factors, including development of short-combine types for mechanical harvesting; expanded needs for starch and tapioca substitutes during the war; development of hybrids in the mid 1950's and a subsequent 20-30% increase in yields; the ability of sorghum to tolerate heat and drought; and acreage allotments on wheat and cotton.

The majority of the U.S. production is for feed grain with a small amount for industrial uses and human food. However, in parts of Africa, Asia and Latin America sorghum grain is the main staple product (Rooney and Clark, 1968).

Sorghum Kernel Structure

The sorghum kernel is a flattened sphere approximately 4.0 m.m. long by 3.5 m.m. wide by 2.5 m.m. thick. Kernel weight varies from 8 to 50 mg (average 28 mg). There are 26 to 35 thousand seeds per kg. The kernel or caryopsis is composed of three main parts, the outer covering (pericarp), the storage tissue (endosperm), and the germ. Each of these parts can be further subdivided. The outside layer of the pericarp is the epidermis or epicarp; it contains pigments and wax. The middle layer, or mesocarp, contains small starch granules embedded in a dense, proteinaceous network. The inner portion of the pericarp (endocarp) is composed of cross-cells and tube cells.

Some sorghums have a highly pigmented cell beneath the pericarp. This has been named a number of different things, namely testa, seedcoat, subcoat, undercoat and nucellar layer.

The endosperm of the sorghum kernel is composed on an aleurone layer and the peripheral, corneous and floury endosperm portions. The aleurone layer, located immediately beneath the pericarp (undercoat, if present), is a layer of small dense endosperm cells with a relatively high content of oil and protein. The peripheral endosperm is located beneath the aleurone layer and consists of a layer several cells thick which is distinguishable from the remainder of the endosperm because the cells are small and contain small starch granules which are emmeshed in a thick proteinaceous matrix. The peripheral endosperm is thicker than in corn. The floury endosperm, located in the center of the kernel, is surrounded by the horny or corneous endosperm. The germ is firmly embedded in the kernel.

Approximately 90% of the total starch and 80% of the total protein are located in the endosperm. The germ contains approximately 75% of the ether extract and 15% of the protein. The endosperm contains 82%, the germ 9.8%, and the pericarp 8.2% of kernel weight (Hubbard, Hall and Earle, 1950). Bidwell et al. (1922) found that the corneous endosperm comprised approximately 49, 55 and 61% of the kernel weight in Dawn Kafir, Dwarf Milo, and Feterita, respectively. The starchy and floury endosperm was respectively 35, 29 and 25% of kernel weight for the same varieties.

Protein quality of the germ portion is more desirable than that found in the endosperm. However, the majority of the protein is found in the endosperm. The protein found in the endosperm forms a matrix around the starch granules. The corneous endosperm is markedly higher in protein content than the starchy or floury endosperm (Bidwell, Bopst and Bowling, 1922).

Chemical Composition

The chemical composition of sorghum grain is similar to corn. The main differences being that sorghum grain is higher in protein and starch and contains less fat than corn. Vitamin content is similar except corn is higher in vitamin A and milo contains more niacin and riboflavin.

The proximate analysis of sorghum grain has been cited by Rooney and Clark (1968) from the works of Miller (1958).

PROXIMATE ANALYSIS OF SORGHUM GRAIN

	Range	Average
Moisture	8-20	15.5
Starch	60-77	74.1
Protein (Nx6.25)	6.6-16.0	11.2
Fat	1.4-6.1	3.7
Ash	1.2-7.1	1.5
Crude Fiber	0.4-13.4	2.6
Sugars (dextrose)	0.4-2.5	1.8
Tannin	0.003-0.17	0.1
Wax	0.2-0.5	0.3
NFE	65.3-85.3	---
Pentosans	1.8-4.9	2.5

Starch. Sorghum grain is valued for its high content of energy in the form of starch. Miller (1958) reports that the amount of starch found in the sorghum grain ranges from 60-77%.

Different types of starches are found in sorghum grain. One kind of starch, amylose, is a polymer of glucose units united exclusively by α-1,4 linkages to give a linear chain. It complexes with iodine to form a blue color. Amylose does not dissolve very readily in water and will percipitate out with the addition of butanol. Amylopectin is more soluble in water or an aqueous butanol solution. It gives a red color with the addition of iodine. Amylopectin has, in addition to α-1,4 linkages, about 5% of α-1,6 bonds that give a branched or bushy structure (Wall and Blessin, 1970).

Generally, corn and sorghum starches have the same properties and can be used almost interchangeably. The starch granules of sorghum grain are usually larger than those of corn (MacMasters, Wolf and Seckinger, 1957). The gelatinization temperature range of sorghum starch is 67^{o} to 72^{o}C. Thus, sorghum starch required more thermal energy, or longer cooling time, for processing (Watson, 1959).

Most sorghum grain starches will contain 20-30% amylose and 70-80% amylopectin. Waxy varieties of sorghum grain will contain almost 100% amylopectin starch.

Proteins. The protein content of sorghum grain is very variable because of climate, soil, cultural practices, and variety (Deyoe, Waggle, and Sanford, 1967).

The proteins of sorghum grain can be classified according to their solubilities. Albumins are soluble in water; globulins, soluble in solutions of salts; prolamines, soluble in solutions of ethyl alcohol; and glutelins, soluble in dilute alcohol. Most sorghum proteins are not extracted with water or salt solutions (Osborne, 1924).

The albumins and globulins are the fraction of sorghum protein that includes enzymes and other biologically active substances.

The predominant proteins in the grain are alcohol-soluble prolamines. Like zein from corn, kafirin is poor in nutritional quality, since it is deficient in several essential amino acids. The amount of lysine, arginine, histidine, glycine, and methionine is low in kafirins. Glutamic acid content is high along with the non-polar amino acids leucine, proline, and alanine.

Glutelin is the second major protein fraction. Glutelins are insoluble in neutral solvents. This insolubility has been attributed to their high molecular weights caused by disulfide bonds in the amino acid cystine, which chemically link different protein chains. These bonds are labile to alkali.

Lipids. The lipids in sorghum are important to animal nutrition but may contribute to the development of off-flavors and rancidity in sorghum-based food products.

Grain fat or oils normally contain relatively low concentrations of free fatty acids. The major portion of fatty acids are combined in mono-, di-, and triglycerides or phospholipids.

Hemicellulose. Whole sorghum grain contains 2-3% pentosans (Edwards and Curtis, 1943). Almost all pentosans are found in the pericarp or bran.

Tannins. Tannins or phenolic compounds contribute flavor and color to sorghum. Phenolic compounds may cause bitterness and unpalatability of the grain and its products. These phenolic compounds are bred into certain strains or sorghums grain to impart resistance to birds. The darkness of seed coat of sorghum grain is an indicator of the amount of tannin in the pericarp. Very dark seed coated sorghum grains are high in tannin.

Bird resistant sorghum grain fed to cattle. In vitro gas production of dry ground bird resistant grain was four times lower than dry ground elevator run sorghum (Hale et al. (1969). Steam processing the bird resistant grain increased its gas production to almost equal steam processed elevator run sorghum grain. Hale et al. (1970) fed steers steamed processed elevator run sorghum and bird resistant grain, and found no performance differences.

Waxy endosperm sorghum grain fed to cattle. Cattle fed all-waxy endosperm milo out performed white endosperm milo (Brethour and Duitsman, 1965) and regular red sorghum of unknown origin (Sherrod, Albin, and Furr, 1969).

Hybrids. Steers fed a white pericarp, hetro-yellow hybrid gained faster and were 11.6% more efficient than steers fed regular sorghum grain of an unknown origin (Drake et al. 1970). McCollough (1970) found small differences in feeding value among four hetro-yellow endosperm hybrids fed to steers. Arehart (1972) fed a white endosperm and a pure yellow endosperm to steers. Steers fed homozygous yellow gained faster and were the most efficient. Hetro-yellow endosperm hybrids produced more efficient gains than white endosperm sorghums (McCollough, Drake and Roth, 1972).

Endosperm texture and starch types for growing swine. Cohen and Tanksley (1973) determined the effect of endosperm texture and starch type of four sorghum grain hybrids on their nutritional value for growing swine. The endosperm textures were classified as floury, corneous, and intermediate (½ floury and ½ corneous). Starch type was designated as normal or waxy. The intermediate textured ration had the highest digestible and metabolizable energy content. There was no significant difference in protein digestibility, gain or feed efficiency due to endosperm texture. There was no significant difference in any parameter measured between the normal and waxy starch diets. The digestible and metabolizable energy values were essentially the same. The normal starch had a higher, but nonsignificant protein digestibility than the waxy starch; however, the waxy starch diet supported higher daily gains and improved feed efficiency.

LITERATURE CITED

Arehart, L. A. 1972. Feedlot performance of cattle fed two hybrid grain sorghums. Ninth annual Rep. page 37. Colby Exp. Sta., Colby, Kansas.

Bidwell, G. L., L. E. Bopst, and J. D. Bowling. 1922. A physical and chemical study of milo and feterita kernals. U.S. Dept. Agr. Bul. 1129, 1-8.

Brethour, J. R. and W. W. Duitsman. 1965. Utilization of feterita type and waxy-endosperm sorghum grains in all-concentrate rations fed to yearling steers. Kan. Agr. Exp. Sta. Bul. 482. page 34.

Cohen, R. S. and T. D. Tanksley. 1973. Energy and protein digestibility of sorghum grains with different endosperm textures and starch types by growing swine. J. Anim. Sci. 37:931.

Deyoe, C. W., D. H. Waggle, and P. E. Sanford. 1967. Protein and amino acid relationships in sorghum grain. 5th Grain Sorghum Res. Util. Conf., Grain Sorghum Producers Assoc. Amarillo, Texas.

Drake, C. L., V. P. Carlson, P. H. Wilson, and D. M. Allen. 1970. White sorghum grain (Funk's G-776W) and elevator-run red sorghum grain compared for fattening cattle. Kan. Agr. Exp. Stat. Bul. 536:38.

Edwards, W. M. and J. J. Curtis. 1943. Grain sorghums their products and uses. Northern Reg. Res. Lab. USDA Peoria, Ill. ACE-193, NM-229.

Hale, W. H., B. Theurer, J. A. Marchello, B. Taylor and H. Essig. 1970. Bird resistant milo and wheat in high concentrate steer fattening rations. Ariz. Cattle Feeder's Day Rep. Page 1-1.

Hubbard, J. E., H. H. Hall and F. R. Earle. 1950. Composition of the component parts of the sorghum kernel. Cereal Chem. 27:415.

MacMasters, M. M., M. J. Wolf and H. L. Seckinger. 1957. Microscopic characteristics of starches in the identification of ground cereal grains. Agr. Food Chem. 5, 455-458.

Martin, John. 1970. History and classification of sorghum. In: Sorghum Production and Utilization. eds. Joseph Wall and William M. Ross. The Avi Publishing Company, Inc. Westport, Connecticut. page 1.

McCollough, R. L. 1970. Feedlot comparisons and digestibility of four hybrid grain sorghums for beef cattle fed all concentrate rations. M.S. thesis, Kansas State University, Manhattan, Kansas.

McCollough, R. L., C. L. Drake, and G. M. Roth. 1972. Feedlot performance of eight hybrid sorghum grains and three hybrid corns. Kan. Agr. Exp. Sta. Rep. 557. page 21.

Miller, D. F. 1958. Composition of cereal grains and forages. Nat'l Academy Sci.-Nat'l Res. Council. Pub. 585. Washington, D.C.

Rooney, L. W. and L. E. Clark. 1968. The chemistry and processing of sorghum grain. Cereal Sci. Today 13:258.

Sherrod, L. B., R. C. Albin and R. D. Ruff. 1969. Net energy of regular and waxy sorghum grains for finishing steers. J. Anim. Sci. 36:223 (Abstr.).

Wall, J. S. and C. W. Blessin. 1970. Composition of sorghum plant and grain. In: Sorghum Production and Utilization. eds. Joseph S. Wall and William M. Ross. The Avi Publishing Company, Inc. Westport, Connecticut. page 128.

Watson, S. A. 1959. The present importance and bright future of grain sorghum. Cereal Sci. Today 4:230.

INTRODUCTION

Limited information is available regarding the effect of endosperm type on the nutritional value of sorghum grain for swine. Production of a homozygous yellow endosperm sorghum grain has increased in recent years with a decline in the production of a homozygous white endosperm sorghum grain. However, the heterozygous yellow endosperm sorghum grains remain the most popular. Overall sorghum grain production has increased without knowing the effect of endosperm type on nutritional value. Yet, if the most efficient endosperm type of sorghum grain for swine is to be found, the plant breeder and animal scientist must work together. Scientists may need to modify gene content or cross different types of cereal grains to find superior endosperm types. If an improved sorghum grain could be developed, it would be a big asset to the swine industry, and help reduce cost of production. Workers in ruminant nutrition have observed specific genetic characteristics of sorghum grains and corn that can influence nutritive value. This study was designed to determine the effects of endosperm type on the nutritive value of sorghum grain for swine.

EXPERIMENTAL PROCEDURE

General. The three endosperm types used in this study were: homozygous yellow, heterozygous yellow, and homozygous white. The same sorghum grain was used for all of the trials. Crude protein and amino acid analysis of each endosperm type is given in table 1.

In the growth trial weight was recorded initially and at 14 day intervals. Daily gain and feed efficiency were determined at the conclusion of the trials. The finishing trial lasted approximately 42 days. Data from the growing trial, finishing trial, and carcass measurements were analyzed using the analysis of variance and Duncans New Multiple Range test (Snedecor and Cochran, 1971).

Trial 1. Sixty-three Duroc pigs averaging 21.4 kg were assigned from outcome groups based on initial weight, litter, and sex to nine pens with 7 pigs per pen representing three replications of the following three dietary treatments: (1) white, (2) heter-yellow and (3) yellow. Composition of the fortified sorghum grain diet for trial 1 is given in table 2. Sorghum grain and soybean meal were maintained at a constant percentage in each diet to insure that a deficiency of an amino acid would not limit utilization of the diet. Pigs were housed in an environmentally controlled nursery. Each group having a pen space 1.83 x 3.35 m. The floor was 10.16 cm. concrete slats with 2.54 cm. slots over an oxidation pit. Temperature was maintained at 22°C for the 28 day growth trial.

Preference Trial. Twenty Duroc and Hampshire pigs averaging 14.5 kg were randomly assigned to two pens of 10 pigs each. Each pen contained three feeders. Each feeder contained one of the endosperm types. The

TABLE 1. AMINO ACID ANALYSIS, %[a]

	Endosperm type		
Amino acid	White	Hetero-yellow	Yellow
Arginine	0.48	0.32	0.42
Histidine	0.29	0.18	0.23
Isoleucine	0.47	0.29	0.36
Leucine	1.69	0.91	1.25
Lysine	0.26	0.23	0.22
Methionine	0.13	0.08	0.12
Phenylalanine	0.60	0.45	0.48
Threonine	0.39	0.27	0.32
Valine	0.59	0.29	0.45
Crude protein, %	12.73	8.14	10.41

[a]Values expressed on a moisture-free basis.

TABLE 2. COMPOSITION OF DIETS (TRIAL 1)[a]

Ingrediet	Percent
Sorghum grain	68.9
Soybean meal (44%)	27.0
Dicalcium phosphate	1.6
Limestone	1.0
Salt	0.5
Vitamin and antibiotic premix[b] and Trace mineral premix[c]	1.0

[a]All diets were pelleted.

[b]Provided the following per kilogram of complete diet: Vitamin A, 4,400 IU; vitamin D_3 330 IU; vitamin E, 22 IU; riboflavin, 5.0 mg; d- pantothenic acid, 13.2 mg; niacin, 27.5 mg; vitamin B_{12}, 24.2 mg; choline, 330 mg; chlortetracycline, 55 milligrams.

[c]Provide the following additions to complete diet (ppm): Zn, 100; Fe, 50; Mn, 27.5; Cu, 5.5; I, 0.75; Co, 0.5.

diets were the same as those used in the growth trial (table 2). Feeders were rotated daily to prevent habit or proximity to waterers from influencing the results.

Digestion Trial. A replicated 3 x 3 Latin square digestion trial was conducted with two groups of three littermate barrows averaging 23.2 kg. Pigs were housed individually in metal metabolism crates allowing for separate collection of urine and feces. Daily feed intake was held constant at 1500 g and fed in two equal proportions at approximately 8:00 a.m. and 5:00 p.m. Water was available *ad libitum*. A five day pre-test period preceded a five day collection period. A ferric oxide marker was used to designate beginning and end of each 5 day collection period. Feces were collected daily and stored in a refrigerator. The entire 5 day collection was dried in a forced-air oven at 50°C for 7 days and allowed to come to air-dry weight, weighed and ground in a Wiley mill through a 40-mesh screen. Urine was collected in a container with approximately 10 ml. of concentrated HCL added to inhibit bacterial growth during the collection period. Each daily collection was diluted to a constant volume of 3000 ml. and a 100 ml. aliquot taken. Accumulated aliquots were stored in a refrigerator until analyzed. Representative feed, fecal and urine samples were analyzed for nitrogen as outlined by A.O.A.C. (1970). The diets used in the digestion trial were the same as those used in trial 1. The barrows were randomly assigned to each of the three treatments described in trial 1.

Trial 2. Eighty-one Duroc, Yorkshire and Hampshire pigs averaging 56.8 kg were allotted from outcome groups based on breed, initial weight, litter and sex. Pigs were assigned to nine pens with 9 pigs per pen representing three replications of the three treatments. Pigs were housed in a modified open-front building, with clear plastic covering the screened front. Each pen was 1.83 x 4.57 m. and contained slatted floors over an oxidation pit. Eight barrows from each treatment were individually removed for slaughter at approximately 100 kg. Feed was supplied *ad libitum* by means of a two-hole feeder. Each pen was equipped with a watering cup. Composition of the diet is shown on table 3. Sorghum grain and soybean meal were maintained at a constant percentage in each diet to insure that a deficiency of an amino acid would not limit utilization of the diet.

TABLE 3. COMPOSITION OF DIET (TRIAL 2)[a]

Ingredient	Percent
Sorghum grain	80.9
Soybean meal (44%)	15.5
Dicalcium phosphate	1.0
Limestone	1.1
Salt	0.5
Vitamin and antibiotic premix[b] and trace mineral premix[c]	1.0
	100.0

[a]All diets were pelleted.

[b]Provided the following per kilogram of complete diet: Vitamin A, 4,400 IU; vitamin D_3 330 IU; vitamin E, 22 IU; riboflavin, 5.0 mg; d- pantothenic acid, 13.2 mg; niacin, 27.5 mg; vitamin B_{12}, 24.2 mg; choline, 330 mg; chlortetracycline, 55 milligrams.

[c]Provide the following additions to complete diet (ppm): Zn, 100; Fe, 50; Mn, 27.5; Cu, 5.5; I, 0.75; Co, 0.5.

RESULTS AND DISCUSSION

Trial 1. Results of this growth trial with growing pigs are presented in table 4. Performance of pigs fed the three endosperm type rations were similar.

Preference Trial. The preference trial results are shown in table 5. Both pens showed a marked preference for the hetero-yellow endosperm sorghum grain diet. The first pen had a preference for the white over the yellow. However, in the second pen, the pigs chose the homozygous yellow endosperm diet over the homozygous white one.

Digestion Trial. The results of the nitrogen metabolism study are presented in table 6. The pigs fed the homozygous yellow endosperm diet showed a slight improvement in percent nitrogen retained and percent nitrogen digestibility. However, the improvement over either the homozygous yellow endosperm diets was not statistically significant at the (P .05) level.

Trial 2. The effects of endosperm type on the performance of finishing pigs is shown in table 7. Pigs on the homozygous yellow endosperm diet had the highest daily gain with the heterozygous yellow endosperm diet having the lowest. However, there was no statistical significance between any of the diets at the (P .05) level. There was a slight increase in the amount of feed consumed by the pigs on the yellow endosperm diet but there was no statistical differences between any of the treatments. Feed/gain ratio was identical for the homozygous white and homozygous yellow endosperm diets with the heterozygous yellow diet having a slightly poorer ratio. Statistically there was no difference between any of the feed/gain ratios.

TABLE 4. INFLUENCE OF ENDOSPERM TYPE ON PERFORMANCE OF GROWING PIGS (TRIAL 1)[a]

	Endosperm type		
Criteria	White	Hetero-yellow	Yellow
Daily gain, kg.	0.71	0.72	0.73
Feed intake, kg.	1.63	1.65	1.66
Feed/Gain	2.30	2.29	2.27

[a]Each value is the mean of 21 pigs with an initial weight of 21.4 kg. Duration of the trial was 28 days.

TABLE 5. EFFECTS OF ENDOSPERM TYPE ON PREFERENCE CONSUMPTION OF GROWING PIGS[a]

	Endosperm type		
Item	White	Hetero-yellow	Yellow
Pen I (kg./pen)	79	294	35
Pen II (kg./pen)	24	290	46
Total	103	584	81

[a]Each pen contained ten pigs and three feeders. Feeders were rotated daily.

TABLE 6. EFFECTS OF ENDOSPERM TYPE ON NITROGEN DIGESTIBILITY AND RETENTION[a]

Endosperm type	N retained %	N digestibility %
White	51.55	84.63
Hetero-yellow	49.84	83.55
Yellow	51.89	84.99

[a]Each value is the mean of six pigs with an initial weight of 23.2 kg.

TABLE 7. INFLUENCE OF ENDOSPERM TYPE ON PERFORMANCE OF FINISHING PIGS (TRIAL 2)[a]

	Endosperm type		
Criteria	White	Hetero-yellow	Yellow
Daily gain, kg.	0.80	0.78	0.83
Feed intake, kg.	2.82	2.78	2.92
Feed/Gain	3.53	3.56	3.52

[a]For the performance data each value is the mean of 27 pigs with an initial weight of 56.8 kg.

Carcass Measurements. The results of the carcass measurements are presented in table 8. Pigs receiving the white endosperm diet possessed the least amount of backfat while pigs receiving the homozygous yellow endosperm diet possessed the greatest amount of backfat. The pigs on the white endosperm diet also had the largest loin-eye areas with the pigs receiving the homozygous yellow diet second and heterozygous yellow diet last. White endosperm diet also possesses the greatest percentage of ham and loin. The heterozygous yellow diet had the second highest percentage of ham and loin followed by the homozygous yellow diet. In all three carcass parameters measured there was not a statistical significance between any of the treatments at the (P .05) level.

The study reported herein is very consistent with previous work concerning sorghum grain endosperm (Cohen et al., 1973). Digestibility coefficients for dry matter, organic matter, and digestible and metabolizable energy were essentially the same for the normal and waxy starch diet. Protein digestibility and nitrogen retention did not differ significantly among the three endosperm textures and the two starch types. In the same study they found grain containing endosperm with an intermediate texture appears to have a nutritional advantage over those with floury and corneous textures. The endosperm with an intermediate texture had a 5.35% advantage in digestible energy over the floury textures.

Copelin et al. (1973) compared protein digestibilities and metabolizable energy values of yellow corn, non-yellow endosperm sorghum grain, hetero-yellow endosperm sorghum grain, and yellow endosperm sorghum grain grown under known conditions. Corn possessed the highest protein digestibility (78.7%) followed by non-yellow (74.2%), yellow (74%) and hetero-yellow (73.4%). The corn diet was highest in energy digestibility (81.3%)

TABLE 8. CARCASS CHARACTERISTICS OF FINISHING PIGS FED DIFFERENT SORGHUM GRAIN ENDOSPERM TYPES (TRIAL 2)[a]

	Endosperm type		
Criteria	White	Hetero-yellow	Yellow
Slaughter wt., kg.	99.10	98.20	99.10
Backfat thickness, cm.	2.92	3.00	3.18
Loin-eye area, cm^2	33.48	31.99	32.38
Ham and loin %	42.56	42.25	41.35

[a]Each value represents the mean of eight barrows.

followed by the yellow endosperm (80.7%), non-yellow (80.2%), and hetero-yellow at (78%). These workers concluded that there was not any significant difference between the milo endosperm types with respect to protein digestibility or metabolizable energy.

The ruminant studies thus far have shown that there is a difference in sorghum grain endosperm types when fed to ruminants. Brethour et al. (1965) compared all-waxy sorghum and white endosperm sorghum grain in feeding steers. Steers fed all-waxy grain had an 11.3% better feed conversion than did the steers fed the white endosperm grain. An all-waxy hybrid was 8% more efficient when fed to steers than a sorghum grain of an unknown origin (Sherrod et al. 1968).

Steers receiving a homozygous yellow endosperm sorghum grain gain 10% faster and were 14.5% more efficient in feed utilization than steers fed a white endosperm sorghum grain (Arehart et al. 1972).

McCollough et al. (1972) reported steers fed hetero-yellow endosperm grain were 10.8% more efficient than those fed white endosperm sorghum grain. McCollough et al. (1972) in a second trial, reported steers fed hetero-yellow endosperm hybrids were 11.5% more efficient than steers fed white endosperm hybrids.

Steers fed all-waxy sorghum grain had a faster rate of gain and a better feed conversion than steers fed white or hetero-yellow endosperm sorghum grains. Steers fed all-waxy sorghum grain had a higher daily gain, and the same feed conversion as steers fed corn (McCollough et al. 1972.)

The results found so far indicate that sorghum grain endosperm types show no nutritional difference for swine. However, ruminants do respond to specific endosperm types.

SUMMARY

Two feeding trials, a digestion trial, and a preference trial were conducted to evaluate the effects of endosperm type on the nutritional value of sorghum grain in swine diets.

In trial 1, 63 pigs averaging 16.8 kg. were used in a 28 day experiment. Pig performance as measured by daily gain, feed per unit of gain, or feed intake was not influenced by endosperm type. A nitrogen metabolism study using 23.2 kg. pigs showed that endosperm type did not influence percent nitrogen retained or percent nitrogen digestibility. In trial 2, 81 pigs averaging 56.8 kg. were used. Daily gain, feed per unit of gain, and feed intake were similar for each endosperm type studied. Carcass measurements utilized were backfat thickness, loin-eye area, and percent ham and loin. These measurements were not influenced by endosperm type. Twenty pigs were used in the preference study. Pigs did show a marked preference for the heterozygous yellow endosperm sorghum grain as compared to the white or yellow endosperm sorghums. There was no difference in pig preference between the white or yellow endosperm. However, pig performance as measured by daily gain, feed per unit of gain, and feed intake was not influenced by endosperm type.

LITERATURE CITED

Arehart, L. A. 1972 Feedlot performance of cattle fed two hybrid grain sorghums. Ninth annual Rep. page 37. Colby Exp. Sta., Colby, Kansas.

Brethour, J. R. and W. W. Duitsman. 1965. Utilization of feterita-type and waxy-endosperm sorghum grains in all-concentrate rations fed to yearling steers. Kan. Agr. Exp. Sta. Bul. 482. page 34.

Cohen. R. S. and T. D. Tanksley. 1973. Energy and protein digestibility of sorghum grains with different endosperm textures and starch types by growing swine. J. Anim. Sci. 37:931.

Copelin, J. L., T. D. Tanksley and J. H. Hesby. 1973. Nitrogen digestibility and energy values of corn and sorghum grains in g-f swine. J. Anim. Sci. 37:277 (abstr.).

McCollough, R. L., C. L. Drake and G. M. Roth. 1972. Feedlot performance of eight hybrid sorghum grains and three hybrid corns. Kan. Agr. Exp. Sta. Rpt. 557. page 21.

Sherrod, L. B., R. C. Albin and R. D. Furr. 1969. Net energy of regular and waxy sorghum grains for finishing steers. J. Anim. Sci. 36:223 (abstr.).

EFFECTS OF ENDOSPERM TYPE ON NUTRITIONAL VALUE OF SORGHUM GRAIN FOR SWINE

By

KENT W. SMITH

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Department of Animal Science and Industry

Kansas State University
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