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A Thesis

Submitted to the Faculty

of

Purdue University

by

Dallas L. Oswalt

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Requirements for the Degree

of

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May 1973

To Jean, Karen and Kris.

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ABSTRACT

Oswalt, Dallas Leon. Ph.D., Purdue University, May 1973. Nutritional Quality of *Sorghum bicolor* (L.) Moench as Estimated by Polyphenols, Crude Protein, Amino Acid Composition and Rat Performance. Major Professors: R. C. Pickett and R. J. Bula.

Selections from 172 samples representing potentially useful germplasm from the World Collection of grain sorghums were analyzed and correlated with weanling rat weight gains to evaluate nutritional quality differences in genotypes.

Significant differences in *in vitro* dry matter disappearance percentages were found among commercial hybrids and selected genotypes which showed a positive correlation to weight gain. *In vitro* dry matter disappearance percentages were negatively correlated with catechin equivalents which were used to indicate low and high concentrations of polyphenolic compounds (tannins) associated with some pigmented caryopses.

Amino acid analyses of the grain showed lysine to be limiting for normal weanling rat growth. Supplementing rations made from grain of genotypes having low catechin equivalent concentration with lysine and with lysine, threonine, methionine and phenylalanine resulted in significantly increased 14-day rat gains. However, similar supplementation of rations made from grain of genotypes with high catechin equivalent concentrations showed no significant increases over unsupplemented ration weight gains.

Partial removal of the pericarp and testa of genotypes containing high concentrations of catechin equivalents lowered catechin equivalent concentrations and rations made from such dehulled genotypes resulted in weight gains similar to rations made from low catechin genotypes with and without amino acid supplementation. Rat weight gains were positively correlated with lysine content of grain in rations made from genotypes containing low catechin equivalent concentrations. However, rat weight gains on rations made from genotypes high in catechin equivalent concentrations were correlated with protein content. These studies indicate that to effectively evaluate nutritional quality factors of grain sorghum, genotypes containing low and high concentrations of catechin equivalents need to be investigated as separate populations.

INTRODUCTION

Grain sorghum, Sorghum bicolor (L.) Moench, is one of the world's four leading sources of food nutrients from cereal crops. It ranks third as a source of food in the arid or semi-arid tropics where several million people live at marginal levels of nutritional requirements. Improving levels of education and methods of communication, increases in the world population, improvements in health care and standards, and higher economic standards of living, all demand more food and improved food quality. The ability to meet the predictable food requirements of the world necessitates the most concerted efforts of all scientists concerned with efficient manipulation of mechanisms of plant inheritance, conservation of crop variabilities and adaptations, and the production of nutritional food sources which maintain acceptability.

Chemical procedures have been developed which can be used to identify and predict components related to nutritional qualities of cereals, but the chemical analyses have not consistently predicted the biological quality or nutrient availability in grain sorghum selections. Variations in the performance of monogastric and ruminant animals utilizing grain sorghum rations having similar levels of crude protein, and carbohydrates, and having similar amino acid profiles suggested that nutritional quality was being affected by factors not measured by any single chemical procedure normally considered. A rapid and

efficient identification of genotypic selections from established genotypes and from segregating populations which have improved nutritional and production factors is paramount to meet future food requirements demanded from grain sorghum producers.

It was hypothesized that: (a) rat weight gains from grain sorghum samples could be correlated with chemical tests indicating nutritional quality of protein which would eliminate the necessity for biological testing of all selections in a screening program, (b) at a given level of protein, grain sorghums differ significantly in animal performance due to factors related to pigmentation and bird resistance, and (c) supplementation of selected sorghum grain samples with identified deficient amino acids would result in rat weight gains similar to complete and balanced rations.

LITERATURE REVIEW

Improvement of the nutritional level of food for millions of people whose major source of food is grain sorghum depends upon improvement of the inherent nutritional quality of the grain sorghums they produce (Rachie 1969). Such improved varieties must be available, adapted and accepted in the near future to satisfy even a portion of the predicted world food needs (Anonymous 1972). Johnson, Schmidt, and Mattern (1968) stated that the need for high quality grain sorghum genotypes is a great challenge to breeders who rely on genetic variability to improve production and nutritional quality. An increasing world population with rising incomes, demands more and better quality meat per capita thus increasing the demand for more feed grain uses of grain sorghum as well as other cereals (Wall and Ross 1970).

Major Nutritional Limitations

Nelson (1969) defines the major nutritional limitations of cereals as being the level of protein which they provide and the balance of amino acids which they contain in relation to nutritional requirements for its utilization as a food or feed. Lysine is recognized as the first limiting amino acid in grain sorghum (Nelson 1969, Nawar et al. 1970) and most cereal proteins (Anonymous 1970). Johnson, Schmidt, and Mattern (1968) defined protein efficiency by the content, balance, and availability of those amino acids present in the cereal that are

essential for animal tissue synthesis and body growth. The identification of genotypes having increased levels of protein and lysine with other essential amino acids balanced for animal tissue production and growth should be the objective of the plant breeder concerned with the nutritional improvement of grain sorghum to be utilized as a source of food or feed.

Genetic Controls of Quality

Nelson (1969) states that it is most probable that the genetically controlled useful differences in protein quality in cereals can be identified when alterations in seed storage proteins have occurred. These alterations in seed storage proteins would be relatively inert in relation to the vital metabolic processes of seed viability and development. The seed could then contain higher levels of nutritionally desirable amino acids that would enhance the use of such seeds as a source of dietary protein.

The identification of opaque-2 and other high-lysine mutants of corn (*Zea mays*) (Misra et al. 1972) has prompted Nelson (1969) to predict that such mutants should be possible in grain sorghum as well as some other cereals. The grain sorghum protein quality improvement project sponsored by US AID at Purdue University (Pickett 1966-1971) has screened numerous samples from the World Collection pool of germplasm by the use of automated amino acid analysis equipment. Pickett (1970) reported crude protein values ranging from 7 to 25 percent with lysine as percent of protein ranging from less than 1.0 to 3.0 percent.

Environmental Factors Influencing Protein Quality

Miller et al. (1964) reported the influences of soil type, fertilization, and moisture as causing the protein to vary from 6.6 to 12.8% in 1961 and from 5.9 to 12.1% in 1962. Pepper and Prine (1972) and Lane (1963) reported the influence of light intensity and quality on maturity and yield of various genotypes. Deyoe and Shellenberger (1965) show variety and location interactions for yield and protein content, however, Schaffert (1972) found genotype by year interaction for yield, but years and locations could be interchanged for protein quality estimations of genotypes. The amino acid composition and distribution was shown to be altered by nitrogen fertilization by Waggle et al. (1967). Clegg and Maranville (1972) found that delayed thinning reduced stem diameter, lowered the number of seeds produced per head and increased seed size. The grain yield was altered by plant height, row width, and plant populations (Atkins and Martinez 1971). Time of harvest as related to stage of maturity and moisture content influenced the chemical composition and digestibility of sorghums studied by Parrett and Riggs (1966). Johnson et al. (1971), Kersting et al. (1961a) and Deyoe et al. (1970) reported an increase in milligrams of protein per 100 seeds, percentages of glutamic acid, proline and leucine in the protein, and in available energy as the grain matured. Immature grain contained higher amounts of lysine, aspartic acid and glycine than mature grain (Deyoe et al. 1970). Johnson et al. (1971) found that the amount of digestible cellulose and protein declined with maturity until frost, at which time an increase in protein digestibility was noted with bird resistant sorghum silages when fed to sheep. These apparent multifactor controls over plant protein synthesis and

deposition have made identification of distinct genetic controls of protein quality and its variations in grain sorghum elusive. To further complicate the utilization of amino acid data it was found in tests conducted at Purdue University that samples having the greatest amounts of bird resistance did not show increased rat weight gains when supplemented with lysine to 125% of the rat requirement (Axtell et al. 1972). These same samples were reported to contain high levels of polyphenols (tannins expressed as catechin equivalents) in the 1970 Annual Report of Inheritance and Improvement of Protein Quality and Content in Sorghum bicolor (L.) Moench, Purdue University (Unpublished report to US AID). Harris, Cummins and Burns (1970) stated that bagging significantly reduced the tannin content and increased the digestibility of the bird resistant varieties. They attributed this to flavor associated with a brown subcoat containing anthocyanogens which they assumed to be precursors of condensed tannins. Collins (1969), Liang et al. (1969), and Bantayehu (1971) concluded that the agronomic characters they studied were not directly related to protein quality or quantity. Liang et al. (1969) further concluded that the most successful way to select for protein content would be by direct selection rather than by some phenotypic character. But direct selection based on chemical analysis of protein content does not give a direct indication of digestibility of protein or its amino acid balance (Maranville 1971, Anthony and Hoveland 1971, Hinders 1971 and 1972, Inglett 1970, Donnelly and Anthony 1969, Waggle et al. 1966, Vavich et al. 1959). However, the amount of protein in a grain sorghum sample is important as well as the amount of protein produced by a given land area (Maranville 1971), when potential sources of protein production are evaluated.

Factors Associated with Pigmented Grain Sorghums

Varieties of grain sorghum having a pigmented testa, dark red or brown colored pericarp are usually identified as having some bird resistance (Tipton et al. 1970) and desirable weathering and storage qualities. Such varieties have been reported by Wall and Ross (1970) to have higher levels of phenolic compounds than those varieties having white, yellow or red pericarp colors.

Bates-Smith and Rasper (1969) identified three distinct layers in the structure of the grain sorghum caryopsis containing variations in pigmentation. The three layers were the epicarp plus the hypocarp, making the pericarp, and the testa separated from the pericarp by a colorless mesocarp. These layers may or may not contain tannins and any one of the layers may be partially or completely absent.

The inheritance of pigmentation related to tannins has been described by Quinby and Martin (1954) and again by Wanjari and York (1972) and classified by Nip and Burns (1969 and 1971). Although "tannins" have been identified among the polyphenols associated with brown pigments, Bates-Smith and Rasper (1969) do not regard the grain sorghum tannins as having all the characteristics of tannic acid and other tannins. Tannins in plants usually have a strong astringency and combine rapidly with hide powder forming an insoluble complex. Barham et al. (1946) found tannins in grain sorghum to be numerous, complex, water soluble, hydrolyzable, mostly condensed, and at relatively low concentrations compared to tannins found in other plants. Blessin et al. (1963) attributes the apparent astringency of grain sorghums to anthocyanogens thought to be precursors of condensed tannins. They

found that 12N hydrochloric acid produced a magenta color with sorghum samples, thus indicating the presence of anthocyanogens, but the color of the pericarp was not related to the presence of anthocyanogens.

Utilization of the genetic controls described by Wanjari and York (1972) makes it possible to remove adverse substances associated with pigments if a given selection would be more nutritious without the pigments associated with or containing catechin tannins.

Morton (1970) has tentatively identified grain sorghum as being one of the plant foods linking together areas of the world having high incidences of esophageal cancer. She further reported that consumption of plants containing sublethal levels of nitrates and nitrosamines are also associated with the utilization of highly pigmented products such as sorghum beers and mashes. Catechin tannins can cause inflammation of the gastrointestinal tract and are apparent tumorigenic factors (Morton 1970).

Production of the highly pigmented grain sorghums persists due to their preferred flavor (Doggett 1970), weather resistant qualities (Wall and Ross 1970), resistance to germination in the panicle before harvest (Harris and Burns 1970), red dye obtained from seed hulls and glumes (Rachie 1969) and resistance to bird damage (Rachie 1969) which helps to insure subsistence yields of grain each growing season. However, McMillian et al. (1972) reported that several lines containing relatively low amounts of tannin appeared to be bird resistant. Thus, quality and quantity of tannins or other associated chemical constituents may be factors influencing so-called bird resistance.

Animal Performance Related to Nutritional Quality

The work showing variable nutritional qualities of selected sorghum samples has often failed to indicate the source of samples, the type of sorghum mixtures or the polyphenol levels of the grain ration and at times the crude protein level of the ration being fed to monogastric or ruminant animals. Some workers indicate the presence of tannins as having a toxic influence on rat growth (Joslyn and Glick 1969) and on chicks (Chang and Fuller 1964, Vohra et al. 1966 and Connor et al. 1969).

Work related to the absorption of nutrients by the intestine of a mouse in the presence of tannic acid by Mitjavila, de Saint Blanquat and Derache (1970) showed that glucose and methionine uptake was depressed by concentrations of 1 mg/l gallotannic acid while the uptake of butyric acid was unaffected by up to 10 mg/l concentrations of gallotannic acid. Potter and Fuller (1965) reported that tannic acid toxicity in chicks was reduced by supplementation with methionine or arginine or both, the effect of both being additive, and the supplementation with choline being as effective as methionine in most of their trials. Saba, Hale and Theurer (1972) reported that tannic acid alone could not account for the decreased utilization of the Aks. 614 bird resistant sorghum in an *in vitro* rumen fermentation study.

Rostagno's (1972) evaluation of sorghum grains showed lowered amino acid content of blood samples taken from very young chicks fed high-tannin sorghums as compared to low-tannin sorghums. He also reported higher levels of fecal nitrogen from high-tannin sorghums than low-tannin sorghums. All of his samples were fed at an iso-nitrogenous level of 15 percent crude protein.

Driedger and Hatfield (1972) indicate that in the ruminant the addition of 10 percent tannin to soybean meal resulted in a 90 percent decrease in deamination of proteins in the soybean meal. Pepsin digestion was found to be unaffected and the pancreatic digestion decreased under their experimental conditions. They recommended the use of tannin to protect plant protein while it passed through the rumen.

Schaffert (1972) indicated that grain sorghum containing tannins gave lower rat growth and that the tannins did not produce a so-called toxic influence or reduce the intake as reported by Fuller et al. (1966), Potter et al. (1965) and Prine et al. (1967). Peterson (1969) reported that technical grade tannin affected feed consumption, chick gain, chemical composition and edible quality of chicken meat, but these factors were not a result of differences in metabolizable energy and protein intake. Glick and Joslyn (1970a, 1970b) reported reduced chick growth on high tannin rations due to factors other than reduced feed intake.

Jambunathan et al. (1973) showed that a difference in distribution of protein fractions by solubility exists between high-tannin and low-tannin samples of grain sorghum. The amount of protein found in the protein solubility fractions highest in lysine was much lower in the high-tannin than low-tannin samples and the fifth fraction accumulated greater amounts of the high-tannin protein complexes. Skoch et al. (1970) did not indicate the tannin content of the samples they used for protein fractionation. However, their results would indicate that two of the varieties they used could have been high in tannin since a large percent of the total protein accumulated in the last protein

fractions. An increase in fraction I and IV would indicate a potential improvement in protein quality (Nelson 1969), rather than the usual increase in the alcohol soluble (prolamines) which accompany normal protein increases in grain sorghum (Virupaksha and Sastry 1968, and Nelson 1969). Thus, the water soluble products isolated from the pericarp fractions of bird resistant samples of grain that precipitated more nitrogen from centrifuged rumen fluid than the soluble substances obtained from non bird-resistant types would be a demonstration of the presence of catechin tannins or pigment associated complexes in the outer layers of the sorghum grain as reported by McGinty (1969a). He showed that mixing polyethylene glycol with the bird resistant grains increased animal performance similar to the results reported by Armstrong et al. (1973) when polyvinyl pyrrolidone was added to chick rations containing bird resistant sorghums or tannic acid supplementation to the level of tannins in the bird resistant samples. This indicates that the complexes found in the bird resistant sorghums do perform in some instances as tannic acid or tannin-like substances (changed solubility of some proteins), but are not true tannins in that they do not form insoluble complexes with hide powder (Bates-Smith et al. 1969).

Pericarp Removal and Effect on Nutritional Quality

Removal of the pericarp and testa layer has been accomplished by Blessin (1971) by using hot sodium hydroxide. This process does not significantly disturb the endosperm or embryo or alter the crude protein content, but is not a process that might easily become economical for large scale usage. The pericarp has been removed along with

other seed parts by use of pearling machines by McGinty (1969b) and Jones and Beckwith (1970). McGinty and Riggs (1968) showed that the addition of the pericarp fraction back to pearled or to low-tannin samples significantly decreased the animal performances. Thus, the factor(s) associated with such reductions of animal growth were associated with the outer layers of the highly pigmented brown sorghums which were removed by the pearling machine. Stephenson et al. (1971) reported, however, that they found no relationship of seed coat color or tannin content with availability of amino acids for animal growth. Several of their low-tannin samples showed low amino acid availability, and both low and high amino acid availability were identified in virtually all colors of pericarp. Maxson and Rooney (1972) and McMillian et al. (1972) are only a few of the workers that have indicated that the mechanism(s) involved with grain sorghum pigmentation and associated phenolic compounds merit further study to clarify the unpredictable nutritional quality of grain sorghum selections based on presently used chemical estimators of monogastric and ruminant animal growth responses.

Interpretation of the literature relative to the comparative effects of low or high tannin sorghum selections is difficult because of unknown levels and kinds of mixtures of protein supplementation, mixtures of sorghum varieties, amounts of sorghum used in the total diet and the complex chemistry of tannins and associated compounds that have not been identified (Wall and Ross 1970). The levels of polyphenols or tannins in the grain used or in the mixed diets have not been stated and most feeding trials have been limited to commercial

hybrids that have many common parents (Deaton and Quisenberry 1967, Kremmerer and Heywang 1965, Roux 1957, and Halloran and Maunder 1971). The identification of the factors resulting in bird resistance, weathering resistance and various other beneficial influences have not been definitely isolated from or associated with the factors causing toxicity, precipitation of proteins or lowered nutritional quality factors (Stephenson et al. 1971).

Chemical and Biological Evaluations of Sorghum Quality

Chemical procedures have been identified to reliably estimate the concentration levels of crude protein (A.O.A.C. 1960), essential amino acid content (Deyoe and Shellenberger 1965), and tannins as catechin equivalents (Maxson and Rooney 1971 and 1972, and Burns 1971) in grain sorghum. Attempts to correlate chemical evaluations with the growth of rats were made by Bernhart (1970). He found the amino acid correlation to be similar in all but sulfur-amino acids and for nitrogen levels.

The use of rats for evaluations of the extensive variation evident in the sorghum germplasm pool have been limited. Unidentified reasons for noted differences in rat growth reported by Nawar et al. (1970) and Howe and Gilfillan (1970) could be attributed to dilution of adverse factors in a given sorghum sample by other ration components, variations in digestibility of carbohydrates in the sorghum samples, or the provision of sufficient protein supplements in the ration that overshadowed any adverse factors.

Trible (1971) indicated that protein in grain sorghum was significantly less digestible (66%) as compared to corn (75%) and wheat (79%) and that there was only 95% the digestible energy in grain sorghum as in corn or wheat when the grains were supplemented with soybean meal, vitamins and minerals in a swine ration containing 17% protein. These differences in carbohydrate availability may be related to identified endosperm types studied by Gorbet and Weibel (1972). The properties of grain sorghum starches were studied by Barham et al. (1946) and they reported no correlation of starch type with protein or tannin content. However, the failure to have identified different endosperm types in an experiment could have resulted in varying animal responses due to available energy differences among samples as indicated by Trible (1971).

Various methods of processing grain sorghum commercially have been discussed by Albin (1971) and Wall and Ross (1970). They reported improved animal responses from waxy endosperm sorghums when steam processed. Cummins (1971) reported the dissipation of tannin in high-tannin grain during ensiling. It would be expected that significant differences in carbohydrate availability exist in the World Collection germplasm pool and that such differences would be altered by processing procedures. The study of the usefulness and potential of the energy within the identifiable grain sorghum genotypes merits considerable effort concurrent with improvement for protein quantity and quality for human consumption and farm animal feeding purposes.

Concerns of Sorghum Breeders Related to Nutritional Quality

Only limited usage of biological methods and procedures have been utilized to evaluate the nutritive quality of grain sorghum. Most of the reported research has been done on a limited range of phenotypes with similar or common genotypic origins. The ability of the sorghum breeder to identify genetic controls of protein quality factors from a segregating population has been handicapped by the lack of data showing correlations of chemical evaluations with simple biological evaluations that significantly relate to monogastric or ruminant animal performance.

The use of the weanling rat as a test animal has been widely accepted and the nutritional requirements of a rat have been documented (Howe and Gilfillan 1970, Mertz 1969, and Rama Rao et al. 1959). The amount of grain required to conduct rat evaluations of nutritional quality is not always available in early stages of breeding and selection programs. Therefore, the concerns of sorghum breeders attempting to improve nutritional quality are: (a) the need to identify the factors that affect nutritional quality associated with pigmentation complexes, (b) development of more rapid screening tests correlated with biological responses that require a minimum of sample, time and equipment, and (c) simple procedures that can be utilized in the field prior to pollination for identification of high quality plants for making specific crosses from random mating and segregating populations.

MATERIALS AND METHODS

Grain samples for all chemical and biological tests were obtained from replicated yield trials or seed increase plots grown on the Purdue Agronomy Farm, Lafayette, Indiana. The commercial hybrid grain samples were grown in 1969 and the other lines and hybrids in 1970 or 1971. Year of production, soil fertility level, size of plots, crude protein and amino acid analyses were utilized in making original sample selections and groupings of the samples subsequently selected for feeding trials. Seed maturity was verified by field data. Low density seed and foreign materials were removed by use of screens and by air separation.

Rat Feeding

Weanling male rats were obtained from the Wistaur Inbred Colony maintained by the Biochemistry Department at Purdue University, West Lafayette, Indiana. Six individually caged rats comprised a replication. The six rats were matched initially by weight and assigned randomly to cages and replications so that each replication had a similar average starting weight. The individually caged rats were placed on feeding shelves in a temperature, humidity, light and noise controlled room at Shuman Laboratories, Battle Ground, Indiana. The rats were provided water and feed ad libitum. Spilled feed was returned to the feeders daily. Individual weight gains were

calculated at the end of 14 days. No respiratory or other illnesses were detected at any time.

To obtain heavier rats for comparison of their growth response to the level of protein available in grain sorghum, weanling rats in excess of the required experimental number were fed a complete commercial ration until they reached the desired weight. The rats were then sorted by weight and randomly assigned to treatments and placement as was done for the smaller weanling rats.

Feed consumed per rat was calculated by subtracting the feed residue from the initial supply and dividing by the number of rats fed in that replication. A feed efficiency ratio was then calculated by dividing the amount of feed consumed by the weight gain and expressed as grams of feed consumed per gram of gain.

Chemical Analyses

The micro-Kjedahl procedure (A.O.A.C. 1960) was used to determine the nitrogen content of selected samples and mixed rations. Percent nitrogen was multiplied by 6.25 to obtain the percent crude protein.

All samples were defatted, hydrolysed and analyzed for amino acid content using an automatic Beckman Model-120 C ion-exchange resin chromatography amino acid analyzer.

Percent oil in whole grain samples was determined at the University of Illinois, Urbana, Illinois, by use of the nuclear magnetic resonance spectroscopy (NMR) technique.

Catechin equivalents were determined as percent of sample by using the vanillin-HCl procedure described by Burns (1971). One gram of grain ground to pass through a 20 mesh screen was soaked in 50 ml

methanol for 24 hours. Standards were prepared by mixing one part of 8% HCl, one part 4% vanillin and 40 mg catechin in 100 ml methanol. New standard curves were prepared daily. One ml of grain-free sample extract was mixed with 6 ml of the vanillin solution and read after 20 minutes at 500 mu on a colorimeter. The readings were then calculated as catechin equivalents from the standard curve established daily from known samples.

The in vitro dry matter disappearance (IVDMD) percentages were determined by use of a modified Tilley and Terry (1963) procedure. One gram of grain was digested at 39 C in 20 ml of nutrient buffer solution and 5 ml of strained rumen fluid. The vials were flushed with carbon dioxide, stoppered and periodically shaken in the stoppered vials which were equipped with gas releases. After 48 hours, 2 ml of 6 N HCl and 0.1 g of pepsin was added and mixed for continued solubilization at 39 C for 24 hours. The samples were then filtered, washed with distilled water and the dry weight determined after drying the samples at 100 C overnight. The loss in weight of a sample was calculated, corrected for rumen fluid solids and reported as the percent of the sample that disappeared during the in vitro digestion procedure (IVDMD).

Whole grain samples were tested for anthocyanogens by heating approximately 1 g of grain in 12N HCl. A magenta color formation indicates the presence of anthocyanogens (Blessin et al. 1963). The colors produced were rated as follows: 1 clear, 2 yellow, 3 magenta, 4 darker red, and 5 dark red and cloudy.

Other Measurements and Statistical Analysis Procedures

Pericarp color was evaluated according to the following scale: 1 white, 2 straw, 3 yellow, 4 orange, 5 light brown, 6 brown, 7 red brown, 8 gray, and 9 purple.

The grain was sectioned by cutting in half and the endosperm classified visually as follows: 3 floury, 5 normal, and 7 corneous. The endosperm was further identified as being waxy or non-waxy (blue-black color produced with iodine solution indicated non-waxy type endosperm).

Standard analysis of variance, correlations, and regressions were calculated according to methods suggested by Steel and Torrie (1960).

Field Data Collection

The number of days from planting until half the plants in the central portion of a plot were flowering half way down the panicles were recorded as days to half bloom.

At the time of seed maturity, height to the top of the panicle of the average plants in the central section of a plot was measured and recorded in centimeters.

Plots utilized for grain yield evaluations and grain sample production were a minimum of 455 cm long with 75 cm between rows. Where heights were known and uniform in the commercial yield trials, 2-row plots were utilized with 305 cm sections harvested from both rows. In other yield trials either the two center rows of 6-row plots or the center row of 3-row plots were used to calculate yields and for obtaining chemical and feeding supplies of grain. Threshed grain from two or more replications in a given experiment were pooled and

completely mixed to insure sufficient grain for feeding trials. Starting at a randomly selected spot within each harvested area of a plot, 10 consecutive panicles were cut, weighed, and subpacketed for obtaining estimates of moisture content at harvest, dry weight, and threshing percentage after being dried and threshed. All panicles in the harvested area of a plot were cut just below the bottom branches and the number of panicles per plot was recorded. Fresh weight of each plot was recorded at harvest time. Plant density for each plot was obtained by use of number of panicles harvested in each plot.

Grain samples were dried at 40 C to less than 12 percent moisture and allowed to equilibrate at room temperature prior to threshing. Samples were threshed, weighed and a Brown-Duvel grain moisture tester was used to determine grain sample moisture content. All yield data were adjusted to 15 percent moisture levels. All grain samples were stored under controlled conditions where the temperature ranged from 15-20 C and the relative humidity ranged from 30 to 40 percent.

Five plants were selected at random from the harvested plants and divided into leaf, stem and panicle components for determining plot yields. Plot dry weights were determined after the components were dried to constant weight (9% moisture) at 45 C. These plant samples were utilized to calculate yields and for chemical analysis.

Feeding Sample Preparation

All samples were uniformly prepared for feeding by cleaning, blowing, grinding, and mixing of 97 g of grain with 4 g mineral mix and 1 g vitamin mix or 96 g of grain with 4 g mineral mix and 2 g vitamin mix unless specified differently in a given experiment.

Grain samples were freshly ground just prior to feeding trials and chemical analyses. The Hawk-Oser salt mixture number three was obtained from Nutritional Biochemical, Inc., Cleveland, Ohio and the Vitamin Supplement was produced by Biochemical Research Products, Chagrin Falls, Ohio. Both contained above minimum levels required for normal weanling rat growth.

A large sample of the line identified as IS (India Sorghum) 2319 was obtained, subdivided and stored unground. These subsamples were used as the check sample for comparisons among samples fed to different groups of rats at different times. Rat weight gains were calculated as actual grams of weight gained and expressed as percent of the check gain obtained with a given set of rats at a given time.

Partial removal of the pericarp and testa was accomplished by steeping the grain for 5 minutes in 60 C water, followed by heating it for 5 minutes in 20 percent sodium hydroxide solution at 60 C. The grain was rinsed six times in water at 60 C, neutralized with 5% acetic acid at 60 C for 5 minutes, washed five times with 60 C water, and dried at 60 C as described by Blessin (1971). This procedure was used to reduce the amount of tannins and/or pigmented complexes measured as catechin equivalents from selected samples of grain sorghum.

Iso-nitrogenous samples were prepared by utilization of crude protein and amino acid analyses of selected representative grain samples. The concentration of crude protein in the grain was determined and the amount of a selected grain sample that would supply a required amount was calculated. The grain sample was then diluted to a selected % protein by the addition of commercial corn starch.

When supplementation of a given amino acid was desired, the amount provided by the grain was calculated and the commercially prepared amino acid was added to bring its level to 125% of the rat requirement (Mertz 1969), replacing equal amounts of the corn starch filler. Thus the major source of protein supplied to the rats was from the grain sorghum samples with a very small amount added via the corn starch and amino acid supplementation. Subsamples of each iso-nitrogenous ration were analyzed after mixing to verify the actual crude protein and amino acid content being fed.

RESULTS AND DISCUSSION

Differences found in IVDMD rates of selected commercial hybrids.

Table 1 shows yield, crude protein concentration, and % of IVDMD for leaves, stems, and grain from selected commercial hybrids. The crude protein concentrations ranged from 8.3 to 13.3% in the grain selections. For some grain samples the IVDMD percentages were lower than expected for grain as compared to IVDMD percentages for stems and leaves. The IVDMD percentages for grain were significantly different among the varieties in this trial and ranged from 3150 to 7070 kg/ha. The range of total solubilized dry matter in the stems, leaves, and grain among hybrids was from 6,800 kg/ha to 11,460 kg/ha. These differences among commercial hybrids led to the subsequently described studies designed to identify the factor(s) in the grain of a specific variety which reduced the solubility rate of the *in vitro* procedure.

In vivo differences of the magnitude demonstrated among these selected hybrids by the *in vitro* results, if and when translated into animal performance, could be of considerable economic importance. For human nutrition, understanding and controlling the factor(s) related to availability of dry matter differences of such magnitudes could be critical for making steps toward improvement or maintenance of health. This would be of primary importance in isolated geographic areas where people are dependent upon grain sorghum as a major food source.

Table 1. Comparisons of yield, protein content, and *in vitro* dry matter disappearance (IVDMD) percentages of selected commercial hybrids (planted June 17 and harvested October 21, 1969 from replicated yield trials on the Purdue Agronomy Farm) (1).

Variety		Plant Part	Dry Matter					
			Yield		Protein		IVDMD(2)	
			%	kg/ha	%	kg/ha	%	kg/ha
DeKalb	A-25	Grain	43	7350	13.3	970	50	3680
		Leaves	15	2530	12.0	300	55	1380
		Stems	28	4820	4.4	210	55	2640
	C-42a	Grain	44	8580	9.7	830	70	6000
		Leaves	18	3490	10.9	380	55	1930
		Stems	22	4440	3.4	160	40	1780
	BR 44	Grain	40	6350	10.0	630	50	3150
		Leaves	16	2480	12.4	300	57	1410
		Stems	30	4720	4.1	190	47	2240
Pioneer	866	Grain	42	9910	9.8	970	71	7070
		Leaves	13	3070	12.0	370	55	1680
		Stems	28	6700	3.7	250	40	2710
	846	Grain	41	8160	9.7	800	67	5500
		Leaves	18	3540	12.7	450	54	1930
		Stems	24	4840	3.9	190	40	1930
Taylor Evans		Grain	40	9960	8.3	820	67	6740
Exp.	11105	Leaves	17	4380	11.1	480	53	2340
		Stems	26	6480	3.1	720	35	2260
RS	610	Grain	41	7360	9.7	720	67	4940
		Leaves	14	2600	12.1	310	60	1580
		Stems	30	5470	3.7	200	41	2260
Averages		Grain	41	8230	10.1	820	63	5300
		Leaves	16	3160	11.9	370	56	1750
		Stems	27	5350	3.7	200	43	2250
C.V. (%)		Grain	4.9	12.1	5.8	11.1	5.9	13.8
		Leaves	6.5	9.3	4.0	11.2	5.0	8.7
		Stems	5.1	12.1	9.6	18.5	4.7	11.4
L.S.D. (.05)		Grain	NSD	NSD	1.4	NSD	5.6	1530
		Leaves	2.5	720	NSD	100	4.2	320
		Stems	3.3	NSD	NSD	NSD	2.9	380

(1) Yields were calculated from 7 replications, two replications were used in the IVDMD calculations, and all plots were fertilized with 309-64-360 kg/ha.

(2) *In vitro* dry matter disappearance percentages as determined by the modified method of Tilley and Terry (1963).

Weanling (50g) rat compared to 80g rat weight gains when fed grain sorghum rations.

Weanling rats have been used extensively for nutritional studies. It was hypothesized that dilution of grain sorghum selections to an iso-nitrogenous level would lower the crude protein content of the rations to below 8% in order to feed the desired samples. The alternatives were to supplement all rations with a fixed amount of crude protein or feed the samples at their natural concentration of crude protein. To avoid confounding protein quality by the addition of some other source of crude protein in the rations, grain sorghum selections mixed with only vitamins and minerals were fed. Considerable variability was found among rats on a selected ration.

Starting weanling (50g) rats on an all cereal diet was thought to cause much of this noted variability among a set of rats. Weanling rats were fed on complete rations until they reached 80g and then compared with 50g weanling rats on rations containing varying concentrations of crude protein and CE. It was hypothesized that older or heavier rats would have a lower protein requirement and thus show less variability than the 50g weanling rats in 14-day weight gains on grain sorghum rations.

It was found that 50g rats showed a lower coefficient of variability than 80g rats (Table 2) and were thus as useful for test animals in samples fed with varying concentrations of CE and crude protein as older rats. These data indicated that the younger rats gained more than the older rats when fed rations made up of the high CE samples and gained less than the heavier rats when fed rations made up of the low CE samples. When considered over both rat sizes and

without regard to CE differences of the grains, weight gains were very similar and the range in weight gains was not related to crude protein concentrations of the rations.

The effect of CE concentrations was evident by the comparison of rations made from RS 610 and BR 64. These selections had similar crude protein concentrations, but differed greatly in rat weight gain. BR 64, which contained a higher CE concentration than RS 610, resulted in significantly less weight gain than RS 610. Further, the 80g rats showed a tendency to gain less than the 50g rats when fed these two grain selections. These data indicated that 50g rats could be used as effectively as 80g rats to compare rat weight gains from grain sorghum samples fed at various concentrations of CE and crude protein.

Table 2. A comparison of 14-day rat weight gains on variable concentrations of crude protein and CE in grain sorghum samples starting with rats having initial weights of 50 and 80 grams (1).

Sample Identification	Catechin Equivalent	Crude Protein	Rat Weight Gain 50 g	Rat Weight Gain 80 g
		%	g	g
RS 610	.48	9.9	5.32	3.59
IS 2319	.51	11.8	14.24	15.98
IS 0062	.52	12.3	12.32	17.56
IS 3982	.63	12.6	8.21	10.29
IS 0075	.97	12.5	2.12	2.25
Low CE Average	.62	11.8	8.44	9.93
IS 6992	4.61	9.3	3.19	2.20
IS 2942	5.70	10.0	2.21	-2.91
BR 64	8.10	9.3	1.54	-2.28
High CE Average	6.14	9.5	2.31	-.99
Average of all		11.0	6.15	5.84
C.V. (%)			.36	.59
LSD (.05)			2.98	7.35

(1) 6 rats were fed per replication. Means of 2 replications are reported.

Use of weanling rats for screening grain sorghums for nutritional quality.

Grain sorghums vary greatly in crude protein, amino acid, pigment, and oil concentrations as well as endosperm types. To correlate chemical data with biological estimates of nutritional quality, weanling rats were fed the grain sorghum samples supplemented only with minerals and vitamins. This reduced the dilution of pigments, carbohydrates, and other factors, but confounded the normal consideration of feeding rations for nutritional quality at iso-nitrogenous levels to avoid differences due to variable concentrations of crude protein. To overcome this consideration, it was hypothesized that crude protein differences could be minimized by observing weight gains within groupings having similar concentrations of protein in the grain. The data shown in Figure 1 indicated that at any selected crude protein concentration, there was a wide range of rat weight gains, expressed as % of the IS 2319 sample fed as a control (% of check). Selections with a high CE concentration tended to result in lower average rat weight gains. These high CE concentrations were found to be associated with a dark colored testa. A dark colored testa was found also on the commercial varieties showing lower rates of IVDMD (Table 1). It was further noted that visual ratings, according to testa and pericarp characteristics, did not consistently predict CE concentrations and subsequent rat response.

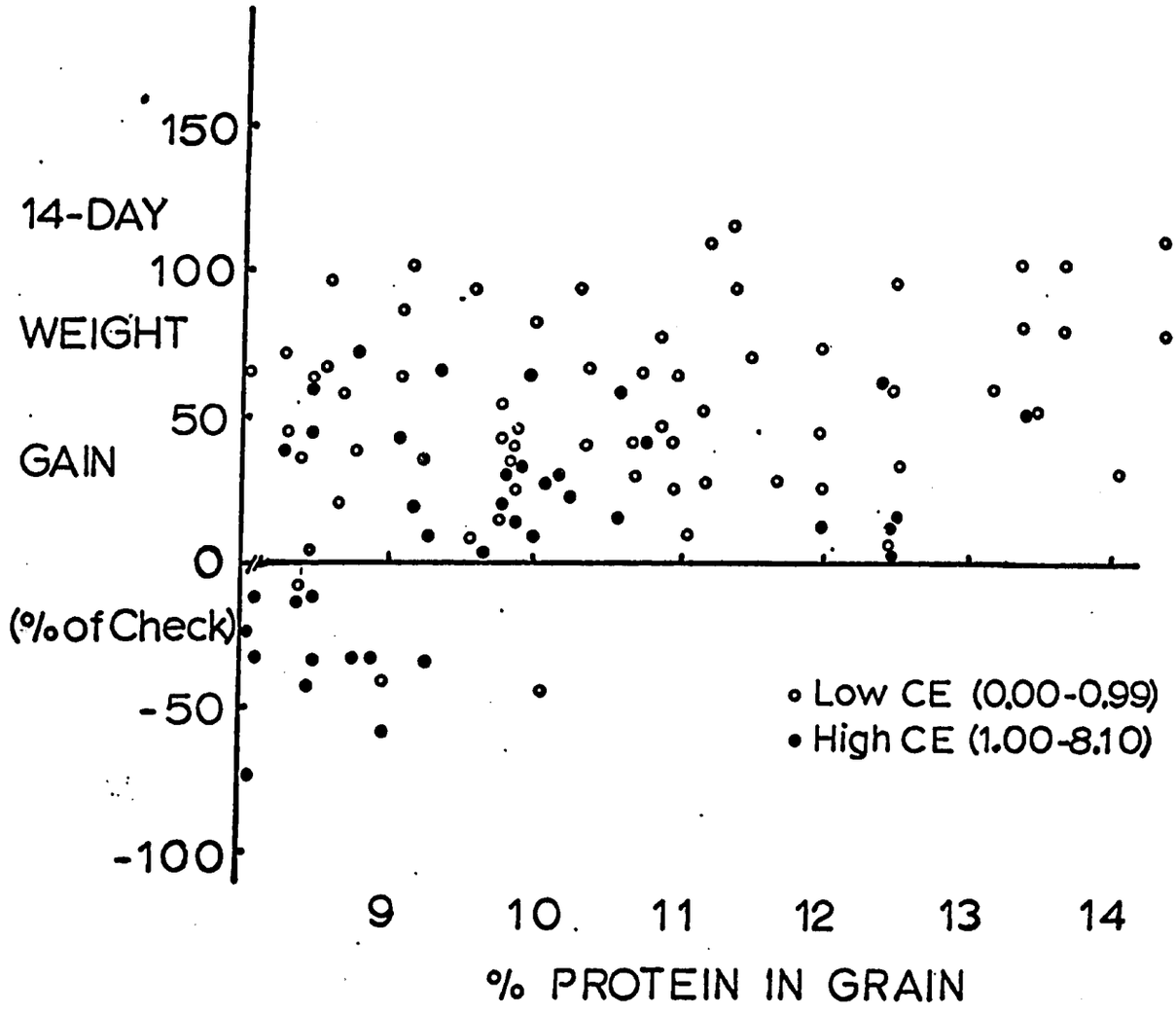

Figure 1. Rat weight gain from 110 grain sorghum genotypes of differing crude protein and catechin equivalent (CE) concentrations.

Relationship of polyphenols (tannins), as measured by catechin equivalents (CE), to the evaluation of grain sorghum nutritional quality.

Data for 172 grain sorghum samples fed to weanling rats over 14-day feeding periods are presented in Appendix Tables 1 and 2. To study the relationships of rat weight gain to chemical analyses, 110 of the 172 samples were chosen to represent a random selection of the range of crude protein and CE concentrations within the genotypes fed. CE concentrations were used as a measure of the amount of polyphenols (tannins) in the grain (Maxon et al. 1972).

Within the 110 genotypes, a natural break seemed evident by the spread in the sample frequency, means for CE concentration and amount of weight gain between the group of samples just below and just above the CE concentration of 1.00 (Table 3). The five groups based on CE concentrations, as shown in Table 3, were then grouped into 66 samples below a CE concentration of 1.00 (low CE group) and 44 samples containing a CE concentration of 1.00 or above (high CE group). Data relative to means and correlations of weight gains with selected means are shown for the high and low groups in Table 4.

Interpretation of the data for all 110 of the selected genotypes (Table 3), when divided into low and high CE concentration groups, was difficult, because correlation of weight gain, as % of check, with grams of lysine per 100 grams of protein (lysine % of protein) was found to be negative rather than positive at low CE concentrations. Amino acid analyses indicated that all genotypes contained less lysine than required for normal growth of weanling rats. Therefore, a positive correlation of weight gain with lysine as % protein was anticipated. However, since these grain sorghum samples were not fed

Table 3. Rat weight gain as related to CE concentrations, IVDMD and correlations with lysine content of 110 selected sorghum genotypes (1).

No. of Samples	CE Range	CE Mean	Protein Mean %	Weight Gain Mean g	Weight Gain Mean % Check	IVDMD Mean %	Correlation (r) of % Check with: Protein %	Lysine % Protein	Lysine % Sample	IVDMD %
42	.00 - .49	.25	10.60	5.75	63	78	.268	.047	.221	.309*
24	.50 - .99	.61	10.79	5.68	62	74	.306	.218	.537**	.656**
11	1.00 - 1.49	1.43	10.38	3.37	27	66	.084	.445	.475	.285
12	1.50 - 3.99	3.13	9.09	3.21	28	58	.552	.035	.416	.281
21	4.00 - 8.10	5.96	9.44	.92	4	55	.751**	-.503*	.046	.295
				Low CE Group						
66	.00 - .99	.38	10.70	5.72	63	77	.280*	.104	.293*	.459**
				High CE Group						
44	1.00 - 8.10	4.13	9.69	2.15	17	59	.392**	-.331*	.055	.301*
				All Samples						
110	.00 - 8.10	1.90	10.28	4.29	44	69	.400**	-.090	.292**	.548**

(1) All rat rations were composed of 94% grain sorghum, 2% vitamin mixture, and 4% mineral mixture.

* Significant at .05 level
** Significant at .01 level

Table 4. Correlations of 14-day weanling rat weight gain, expressed as percent of check, with percent protein, amino acids as percent protein and selected factors.

Selected Factors	Low CE Samples 66 Means	High CE Samples 44 Means	Low CE Samples 66 r	High CE Samples 44 r
Weight gain (% of check)	63	17	1.000	1.000
% Protein	10.63	9.69	.292*	.392**
CE	.38	4.13	.049	-.472**
Weight (g)	5.75	2.28	.788**	.928**
Days Flower	80	82	-.074	-.098
Height (cm)	183	187	.408**	-.015
HCl test	2.91	3.94	.234	-.176
% Oil	3.13	3.21	.184	.174
IVDMD	77	59	.444**	.301*
100 seed (g)	2.46	2.36	.051	.247
mg P/seed	2.78	2.43	.214	.364*
mg L/seed	.062	.055	.276	.244
Pericarp	4.08	5.74	-.087	-.360
Endosperm	5.36	4.47	-.217	-.171
Lysine % of sample	.254	.233	.278*	.055
Meth+Cyst	2.64	2.80	.001	.305*
Iso/Leuc	.289	.292	-.071	-.331*
Lysine	2.29	2.33	.088	-.373**
Histidine	2.22	2.56	-.346*	.217
Arginine	4.05	4.17	.112	-.066
Asp. acid	7.31	7.17	-.006	-.190
Threonine	3.23	3.19	-.120	.012
Serine	4.42	4.37	-.064	.200
Glu. acid	22.98	22.44	-.075	.316*
Proline	8.05	7.72	-.103	.605**
Cystine	1.25	1.32	-.352**	.273
Glycine	3.21	3.25	.013	-.238
Alanine	9.75	9.67	-.196	.233
Valine	5.21	5.11	-.093	-.013
Methionine	1.41	1.53	.157	.239
Isoluecine	4.11	4.05	-.268*	.148
Leucine	14.14	13.91	-.237	.278
Tyrosine	4.88	4.60	-.081	.397**
Phenylalanine	5.35	5.35	-.280*	.114

* Significant at .05 level
** Significant at .01 level

at iso-nitrogenous levels, the varying levels of protein confounded the direct use of lysine expressed as percent of protein as a measure to predict protein quality and thus be a predictor of rat weight gains. Had the selected samples all been fed on an iso-nitrogenous basis, then lysine as percent of protein would have been equivalent to lysine content or lysine as % of sample (grams of lysine per 100 grams of sample). As fed in this study, correlation of weight gain with lysine expressed as percent of sample, for the low CE concentration group of samples, showed the expected dependency of rat growth on lysine % of sample (r=.293*). However, the high CE group did not show a significant correlation of weight gain with lysine % of sample (r=.055) which is indicative of an overshadowing influence of the factors associated with high concentrations of CE on nutritive quality of sorghum grain.

Weight gains (g) for 48 low CE samples and 35 high CE samples were plotted against their respective lysine percent of sample (Figure 2 a & b) and protein percent of sample (Figure 3). The regression of rat weight gain on lysine % of sample for the low CE samples was positive (r=.290*), but for the high CE samples the regression of weight gain on lysine % of sample was not significantly different from zero (r=.055). These differences indicated that the low and high CE samples should be studied separately due to factors associated with the high CE concentrations which reduced rat weight gains more than the lysine content which normally limits rat growth in cereal crops. The lysine content was lower in these samples than the amount required for normal rat growth. (See discussion later and Figures 5 and 6).

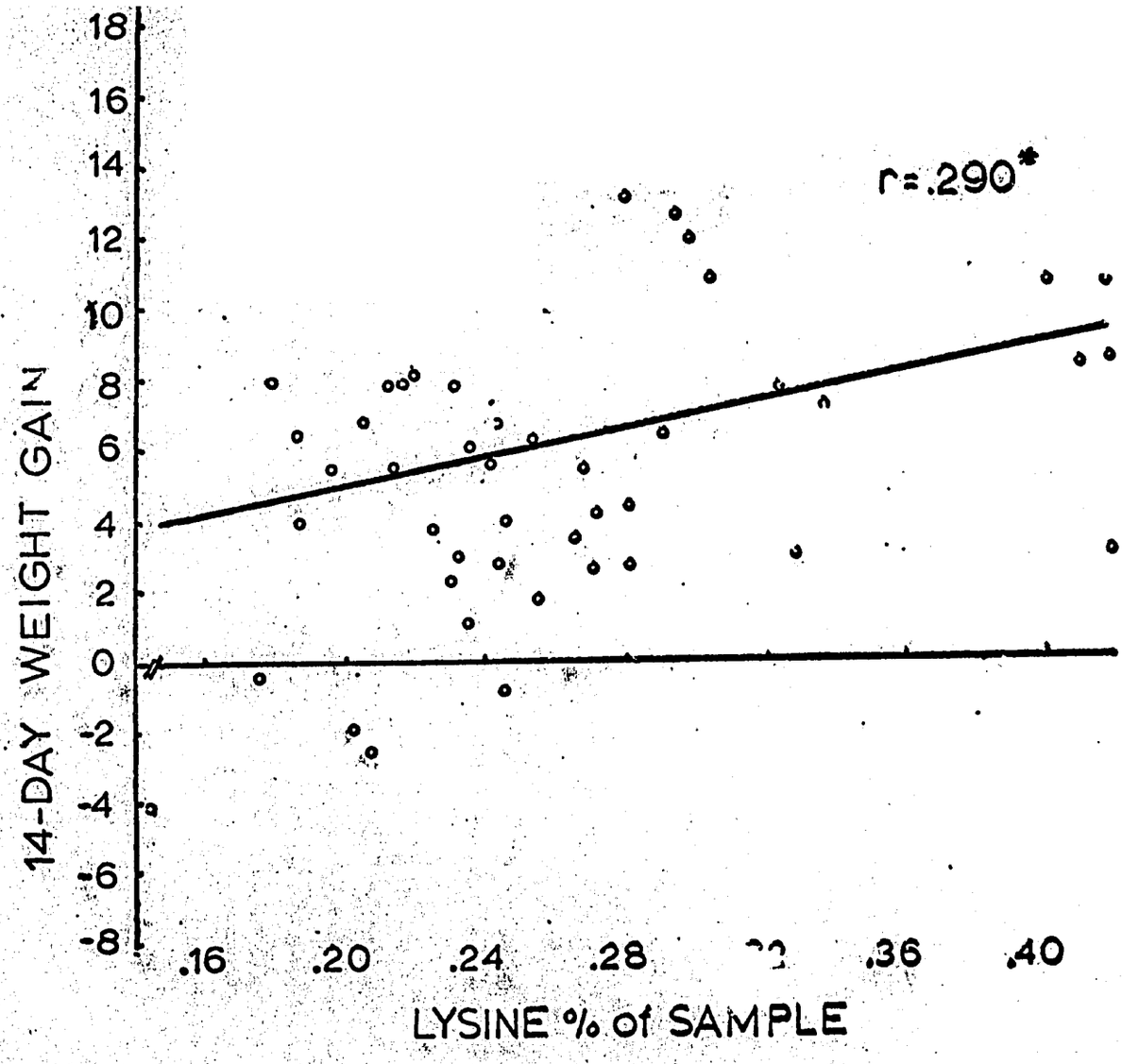

Figure 2a. Regression of rat weight gain (g) on grams of lysine per 100 grams of sample for 48 low CE concentration grain sorghum samples.

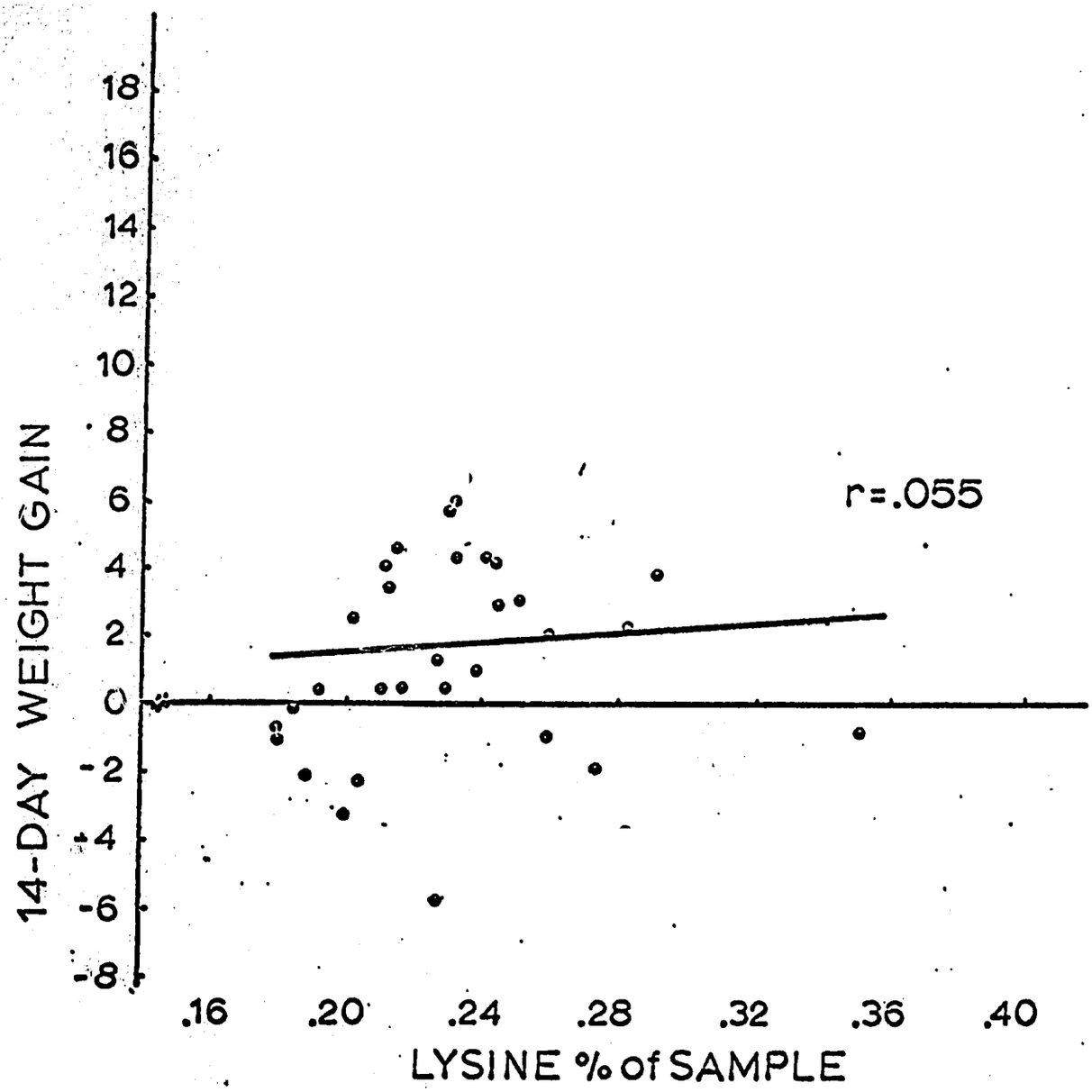

Figure 2b. Regression of rat weight gain (g) on grams of lysine per 100 grams of sample for 36 high CE concentration grain sorghum samples.

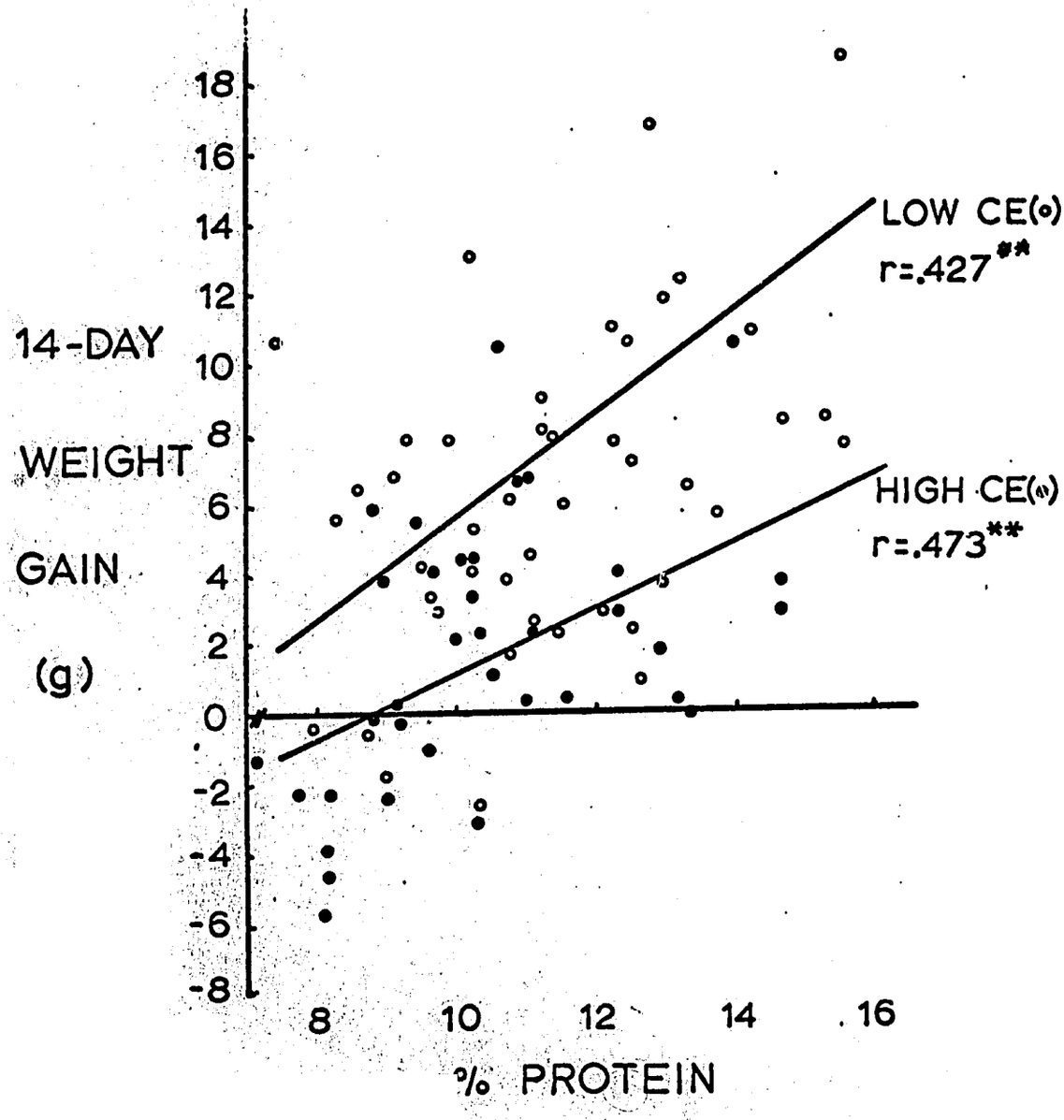

Figure 3. Regression of rat weight gain (g) on percent crude protein in 48 low and 36 high CE concentration grain samples.

Rat weight gains from low and high CE genotypes showed a positive response to increased protein content as anticipated (Table 3 and Figure 3). Since the low CE sample weight gains were correlated with both % crude protein and lysine % of sample and the high CE weight gains were correlated only with % crude protein, this would suggest that the limiting factor in the high CE sample was associated with % crude protein and its availability rather than lysine % of sample. This is supported by the lower weight gains obtained at a given % crude protein and the difference in the regression lines shown in Figure 3 which is lower for the high CE samples than for the low CE samples (Schaffert 1972). However, the regressions for low and high CE group weight gains on % crude protein were not statistically different.

The high level of error associated with these data, representing the means of six rats fed in unreplicated rat trials at inherent crude protein content, limits their use to general implications. In the screening of large numbers, identification of extremes was possible and useful to select genotypes within the high and low CE concentrations for more detailed iso-nitrogenous studies of factors associated with the CE concentrations and the nutritional quality of grain sorghums.

Use of the <u>in vitro</u> dry matter disappearance (IVDMD) procedure (modified Tilley and Terry 1963) for estimating rat weight gain and thus estimating the nutritional quality of grain sorghum was shown by the data in Table 3. The mean IVDMD for each CE group was consistently lower as the CE mean increased. The correlation of weight gain as % check was positively correlated with IVDMD for low CE samples (r=.459**), high CE samples (r=.301*) and all samples together (r=.548**).

Correlations of IVDMD with CE concentrations (not shown) were r= -.185 for the low CE samples, r= -.457** for the high CE samples and when considered all together r= -.623**. These data indicate that IVDMD percentages were reliable estimates of nutritional quality in groups of grain sorghum where high and low CE samples were studied together or when high CE samples would be studied in a separate group. The IVDMD percentage was a good estimator of the combined influences of crude protein and CE concentrations as shown by the IVDMD means and their correlations with weight gain.

Comparison of rat weight gains in high and low CE groups of grain sorghum genotypes at near iso-nitrogenous levels.

Each of the near iso-nitrogenous groups had similar CE values (Table 5). The average crude protein and lysine as % protein concentrations of the low and high CE groups at a given level of crude protein were similar. However, the lysine content (g of lysine per 100g sample) increased as the % crude protein levels increased. This indicated that the % lysine in the crude protein remained constant or decreased only slightly as the % crude protein increased. Thus, in the low CE samples as the % crude protein increased the lysine as % sample increased and this resulted in an increase in rat weight gain.

Increased weight gain was also indicated in the low CE group by the general increase of the IVDMD percentages. High CE group means were consistently lower in rat weight gains (except at the 10% crude protein level), rat weight gains expressed as % of check and IVDMD % for all levels of crude protein as compared to the low CE sample means. Two of the eight genotypes in the high CE group at the 10%

Table 5. Comparisons of means of grain sorghum genotypes grouped by crude protein levels and high and low concentrations of catechin equivalents (CE).

No. of Samples	C.E.	Protein %	Rat Weight Gain g	Rat Weight Gain % Check	IVDMD %	Lysine* % Sample	Lysine* % Protein
			Below 8.9% crude protein				
12	.40	8.37	4.10	47	70	.20	3.00
17	4.00	8.24	.13	1	55	.23	2.82
			From 9.0 to 9.9% crude protein				
15	.26	9.63	4.87	46	74	.24	2.59
13	4.96	9.48	2.39	17	52	.22	2.64
			From 10.0 to 10.9% crude protein				
11	.51	10.47	5.19	71	73	.25	2.75
8	4.09	10.34	5.20	39	68	.24	2.96
			From 11.0 to 11.9% crude protein				
13	.34	11.26	6.86	66	84	.28	2.45
0							
			From 12.0 to 14% crude protein				
15	.42	13.19	6.94	80	80	.30	2.50
6	2.21	12.58	3.33	30	71	.26	2.75

* Lysine rat requirement is 1% of sample (Mertz 1969).

crude protein level gave unusually high rat weight gains and thus caused the mean weight gains for this protein level to be higher than would be indicated for the other high CE samples in the protein level group.

Weight gains increased in the low CE genotype as the % crude protein and the lysine content of the sample increased. Likewise weight gain expressed as % of check for the high CE samples showed a general increase as % crude protein increased but at much lower levels (1-39) than for the low CE samples (46-80). This showed that CE concentration was a dependable indicator of the presence of a factor(s) in the high CE genotypes which resulted in reduced rat weight gain at a given crude protein and lysine content.

Data in Table 5 showed, as was indicated in Table 3, that the IVDMD procedure was an effective method of predicting rat weight gain when CE, crude protein and lysine concentrations of a given sample were considered simultaneously. This was especially true when samples were studied at various levels of crude protein in order to screen large numbers of samples having relatively limited amounts of grain for feeding purposes. These data indicate that the IVDMD procedure would be useful to identify genotypes having exceptional nutritional quality for detailed isonitrogenous or other studies that could lead to the identification of the specific factors in a genotype related to its inherent nutritional qualities and inheritance of these qualities.

Supplementation of high and low CE commercial grain sorghum rations for weanling rats with choline and methionine.

Methionine and choline are potential methyl donors (Mitjavila et al. 1970) that could be expected to furnish methyl groups for the breakdown of tannins in the intestinal tract of a rat. Since it is thought that the test for CE concentrations measures tannins, weanling rats were fed a low CE selection (RS 610) and a high CE selection (BR 64) ration supplemented and unsupplemented with methionine and choline alone and in combination with each other.

No significant differences in weight gains, feed consumed or feed efficiency ratios were found for any of the rations containing RS 610 (Table 6). However, BR 64 fed unsupplemented or supplemented with methionine or choline alone showed a significantly lower rate of rat gain than the rations made with RS 610 and low in CE. The feeding of choline with methionine as a supplement in the BR 64 ration showed weight gains and a feed efficiency ratio similar to that of rations from RS 610. In addition, the amounts of feed consumed on each of the 4 BR 64 rations were similar to the RS 610 containing rations.

These data indicate that some factors limiting rat growth in the BR 64 rations were corrected for rat growth when both methionine and choline were added simultaneously to the grain sorghum ration containing the high CE concentration. The data showed, in addition, that feed consumption was not significantly reduced for the 3 BR 64 rations which produced the lowest amount of rat weight gain. Thus, palatability or acceptability in this trial was not the factor causing the high CE concentration sample (BR 64) weight gains to be significantly lower

Table 6. Supplementation of low (RS 610) and high (BR 64) CE commercial grain sorghum rations for weanling rats with methionine and choline *.

Sample Identification	14-day Weight Gains g	Feed Consumed g/rat	g feed/ g gain
RS 610 (low CE group: 0.48 CE)	5.27 a	112 a	21 a
RS 610 + methionine (1)	5.95 a	107 a	18 a
RS 610 + choline (2)	4.05 a	117 a	28 a
RS 610 + methionine + choline (3)	6.50 a	105 a	16 a
BR 64 (high CE group: 8.10 CE)	1.31 b	116 a	88 b
BR 64 + methionine (1)	.91 b	97 a	106 b
BR 64 + choline (2)	.76 b	136 a	179 b
BR 64 + methionine + choline (3)	4.39 a	129 a	29 a
Average	3.64	115	
C.V. (%)	45	9	

* Numbers followed by the same letters are not significantly different at the 5 percent level based on Duncans multiple range test. All values are the average of 2 replications containing 6 rats each fed for a period of 14 days. All rations contained 2% vitamin mixture and 4% mineral mixture.

1) Methionine was supplemented at the rate of .15 g per 100 g of ration.

2) Choline was supplemented at the rate of .20 g per 100 g of ration.

3) Methionine and choline were supplemented at .15 g and .20 g respectively per 100 g of ration.

than the RS 610 ration gains. The apparent benefit from combining methionine with choline is not understood and merits further investigation.

The effect of dehulling and lysine supplementation of high CE grain sorghums on weanling rat weight gain.

Removal of the outer layers of the caryopsis with hot sodium hydroxide lowered the CE (tannin) level of the remaining grain without significantly altering the crude protein content of the grain as Blessin (1971) had reported was possible (Table 7). Amounts of feed consumed by rats fed rations based on dehulled grain was not significantly different from whole grain rations. However, the feed efficiency ratio was higher for the whole grain sample of BR 64 which contained a higher CE concentration than the low CE selection fed (RS 610) and the dehulled samples. This indicated that the factor(s) associated with the CE concentration test were removed by the dehulling procedure and that weanling rats could then gain weight on the dehulled-sample ration at a rate similar to weight gains obtained from low CE selections. The data indicated that dehulling did not alter the rate of weight gain, feed consumed or the feed efficiency ratio for the low CE selection, but did remove the factor(s) measured by the procedure to determine high CE concentrations that were causing reduced rat weight gains.

Supplementation with lysine of two high CE samples did not significantly increase 14-day weight gains for weanling rats (Figure 4). However, dehulling grain of these genotypes did result in increased weight gain and an additional increment of weight gain resulted when the dehulled samples were also supplemented with lysine. Dehulled

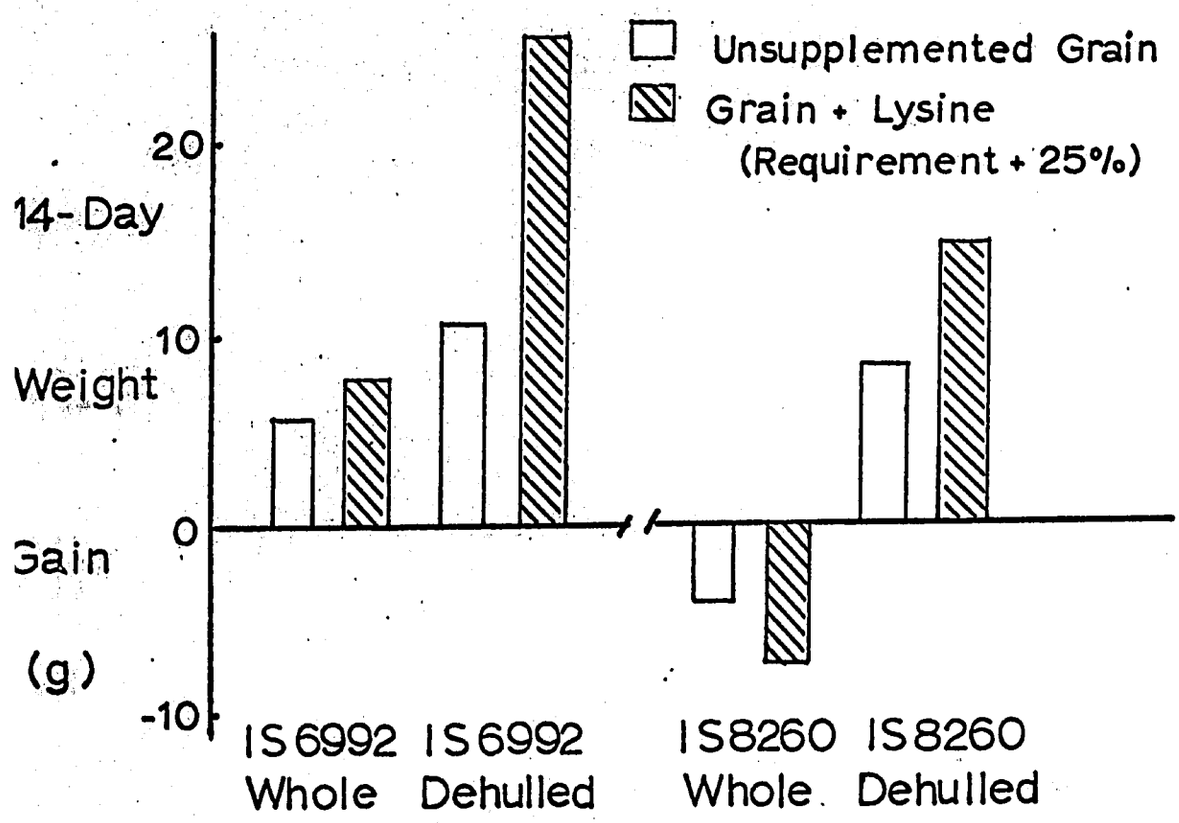

Figure 4. Rat weight gain on rations with and without lysine supplemented whole and dehulled high CE concentration grain sorghum genotypes.

IS 6992 supplemented with lysine produced rat weight gains similar to those of low CE grain sorghum genotype rations for a 14-day period. Apparently, factor(s) related to poor rat growth present in high CE sorghum lines were removed by the dehulling process since the weight gains following dehulling were similar to those of low CE lines with and without lysine supplementation.

Table 7. Effect of alkali dehulling of grain on rat weight gain or a high and a low catechin equivalent (CE) grain sorghum ration.

Identification	C.E.	Protein %	14-day Weight g	Feed Consumed g	g feed/ g gain
RS 610 (Whole)	0.48	9.90	5.27	112	21.3
RS 610 (Dehulled)	0.10	9.95	6.73	132	19.6
BR 64 (Whole)	8.10	9.30	-.99	122	--
BR 64 (Dehulled)	.35	9.38	8.42	118	14.1
Mean			4.86	121	
C.V. (%)			42	01	
L.S.D. (.05)			6.47	28	

Essential amino acid content of high and low CE grain sorghums compared to weanling rat amino acid requirements and rat gain responses to amino acid supplementation.

Concentrations of nine amino acids considered essential for normal weanling rat growth are shown as grams of amino acid per 100 grams of protein of grain sorghum in Figure 5. The means for 36 low and 34 high CE concentration grain sorghum genotypes are compared to the weanling rat requirements. The mean protein concentration for the low CE samples was 11.61% while the mean for the high CE samples was 10.33%.

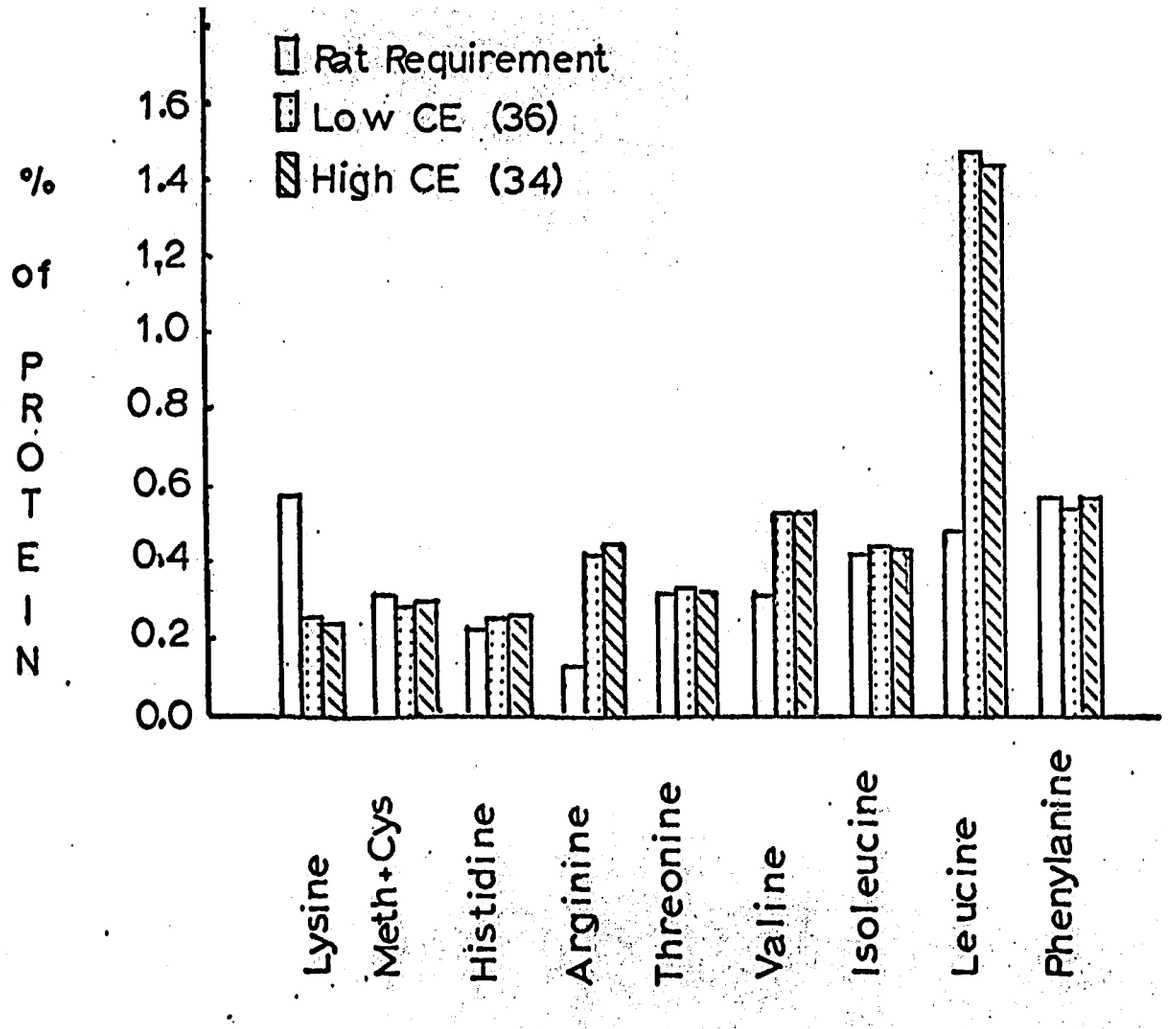

Figure 5. Comparison of weanling rat essential amino acid requirements expressed as percent of protein with high and low polyphenol (CE) grain sorghum selections.

In Figure 6, similar comparisons are made except the amino acid values are expressed as grams of amino acid per 100 grams of sample. Essentially no differences in amino acid concentrations were apparent between the high and low CE selections. The slight difference was consistent and due to the lower crude protein concentration found in the high CE selection means as compared to the low CE selection means.

Expressing the amino acids as % of protein (Figure 5) or as % of sample (Figure 6) showed concentrations of lysine in the grain samples to be very low compared to the weanling rat requirement for normal growth. In addition, the amounts of leucine and arginine were shown to be present in concentrations of more than double the weanling rat requirement. These excessive amounts could be expected to be potentially toxic to normal weanling rat growth (Mertz 1972). Grain sorghums would appear to be also deficient in methionine, threonine and possibly in isoleucine and phenylalanine when compared to concentrations of these amino acids required by weanling rats expressed as % of sample (Figure 6).

To test the validity of supplementing grain sorghums with lysine alone, as indicated, being the only amino acid needed when expressing amino acids as % of protein (Figure 5), compared to the need for additional amino acids when they were expressed as % of sample (Figure 6), two low CE grain sorghum samples which possess a complete or partial testa, but which were both low in CE concentration and one sample containing a high concentration of CE were fed at iso-nitrogenous levels in replicated trials. Rations composed of the selected grain sorghum (94%), mineral mixture (4%), and vitamin mixture (2%) were fed 14 days unsupplemented or supplemented with sufficient lysine to bring

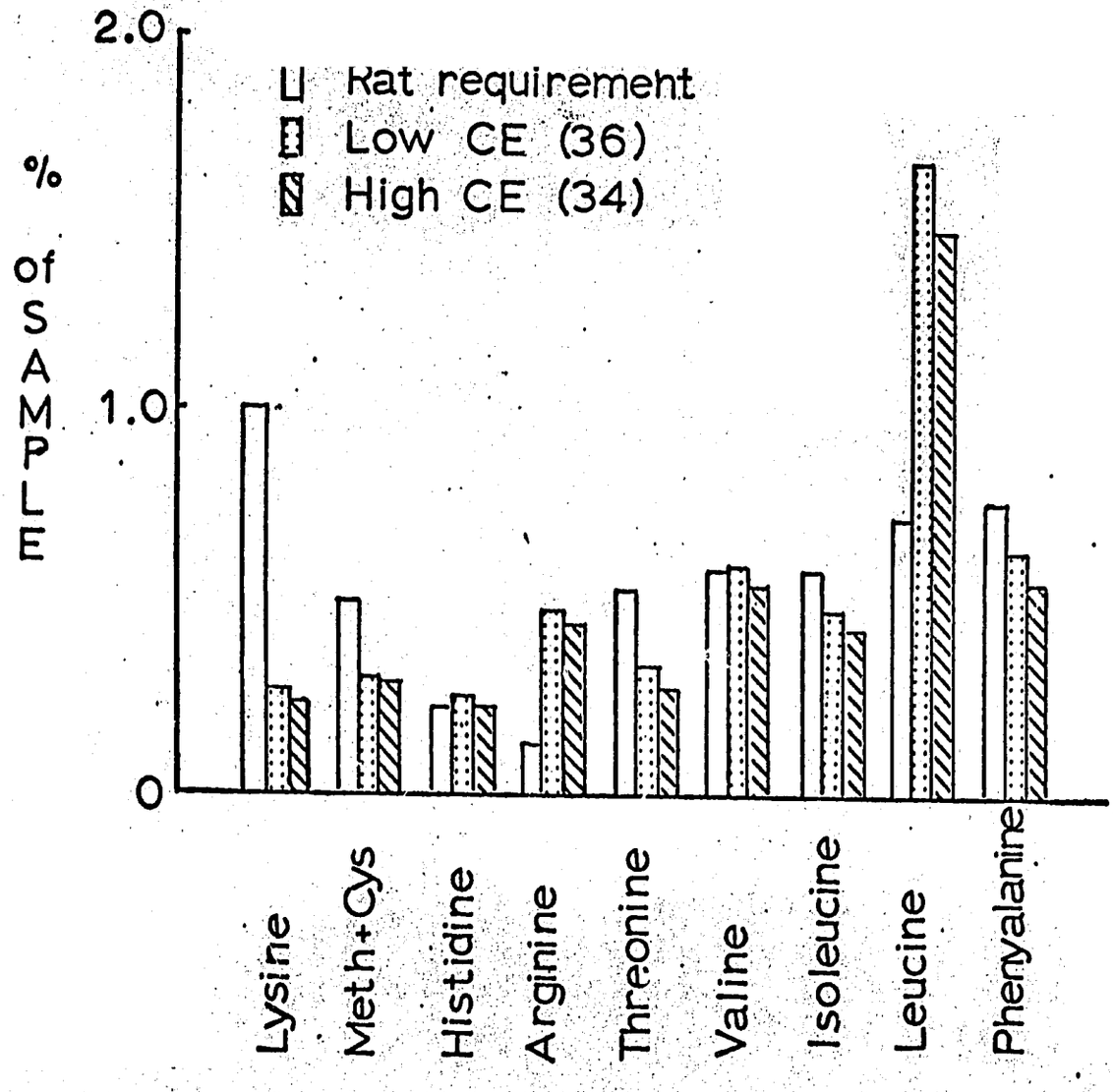

Figure 6. Comparison of essential amino acid requirements of weanling rats with high and low polyphenol (CE) content of grain sorghum.

the content up to 125% the rat requirement for normal growth. Figure 7 shows that IS 2319 responded well to lysine supplementation and that IS 0129 also responded significantly to lysine supplementation by increased rat gain. However, lysine supplementation of the ration based on the high CE selection (IS 6992) did not result in normal rat gains. Data in Figure 4, discussed earlier, showed that IS 6992, if dehulled, did respond favorably to lysine supplementation.

To test the influence of toxicity due to excessive amounts of arginine and leucine indicated in Figure 6, and to test the influence of supplementation with additional amino acids, the same grain sorghum samples discussed in the previous section and shown in Figure 7 were supplemented with lysine alone and with lysine in combination with methionine, threonine and phenylalanine. Each of the amino acids were supplemented to 125% of the rat requirement based on grams of amino acid per 100 grams of the mixed ration. Data presented in Figure 8 indicated that the addition of all four amino acids, significantly increased rat gains when fed iso-nitrogenous rations containing grain from the low CE genotypes. The slight increase in weight gain noted for the high CE genotype was not significant at the .05 level of probability. The lack of weight gain by weanling rats when fed IS 6992 (high CE) supplemented with lysine and when supplemented with all four amino acids again points out the difference between selections that contain high and low CE concentrations. In order to effectively identify the nutritional potentials of the sorghum genotypes containing high concentrations of polyphenols (tannins or tannin-like compounds) measured as CE concentrations (catechin equivalents), the samples must

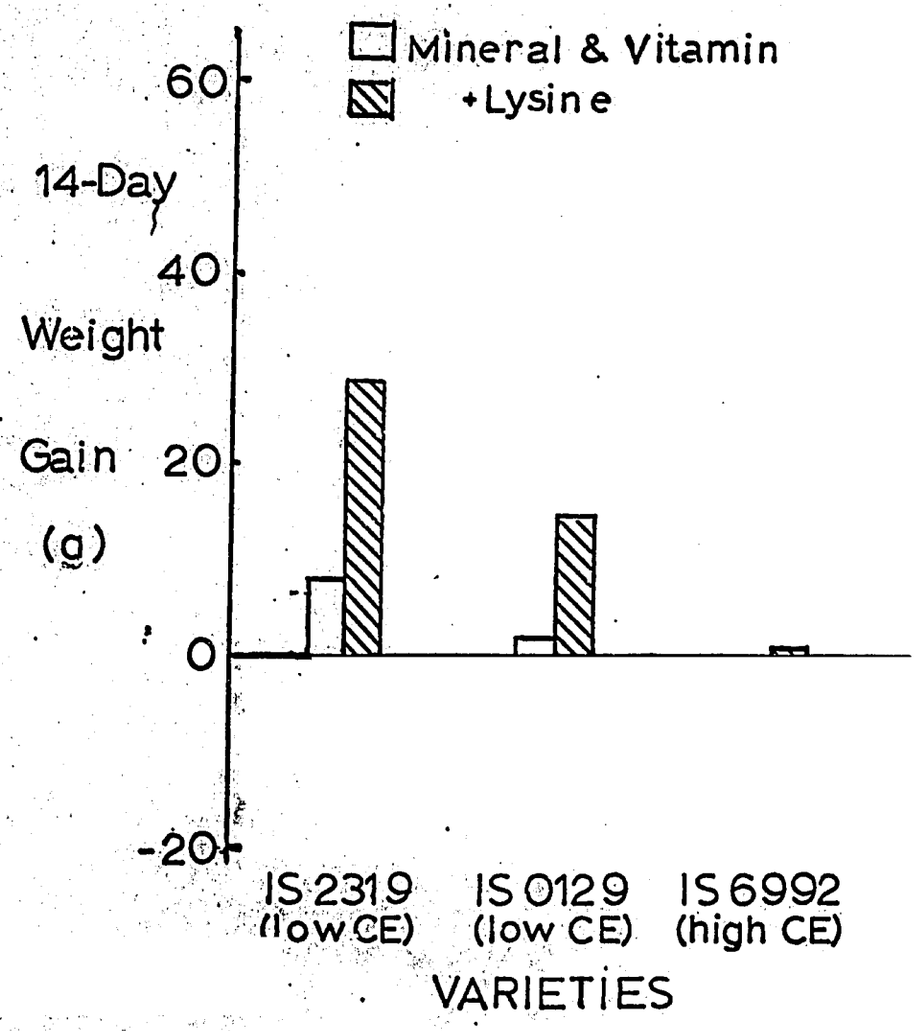

Figure 7. Influence of lysine supplemented compared to not supplemented iso-nitrogenous low and high CE concentration grain sorghum rations on 14-day weanling rat weight gain.

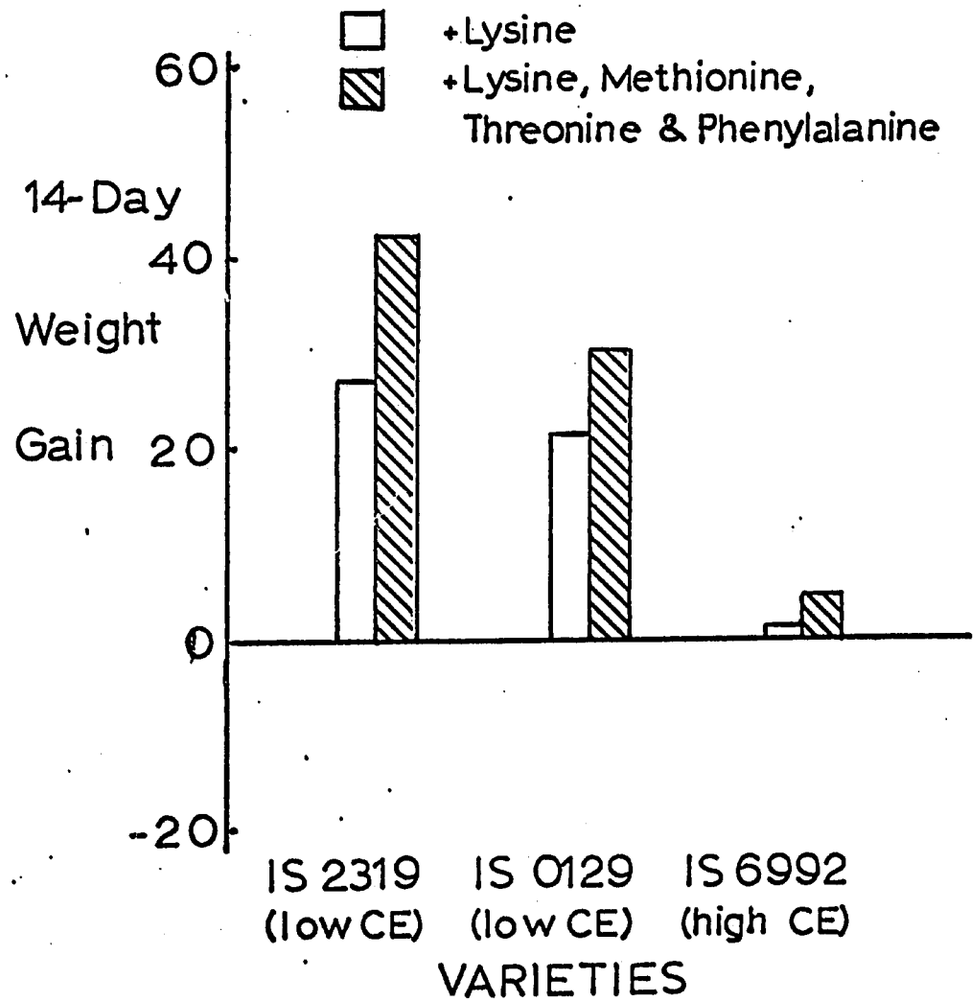

Figure 8. Influence of lysine and lysine, methionine, threonine and phenylalanine supplemented iso-nitrogenous low and high CE concentration grain sorghum rations on 14-day weanling rat weight gain.

be dehulled or have these pigment-associated substances de-activated before normal rat growth at the inherent level of crude protein can be obtained.

Work reported by Schaffert (1972) indicated that supplementing high CE genotypes with soybean meal (and likely other forms of protein) can result in normal rates of rat growth if sufficient protein was supplied by the soybean meal. Work reported by Rostagno (1972) indicated that such supplementation would result in increased fecal losses of protein compounds, and the 4 amino acids used to supplement the high CE sorghum did not improve significantly rat weight gain. Therefore, total protein is indicated as being the primary limiting factor for rat growth in rations containing high concentrations of CE.

The amount of weight gained on the rations of low CE sorghums supplemented with all four amino acids indicated that in the 14-day period measured in this experiment, the excessive amounts of arginine and leucine did not significantly retard rat weight gains since gains in excess of 3 grams per rat per day were observed.

SUMMARY AND CONCLUSIONS

Wide variations in commercial hybrid grain sorghum *in vitro* dry matter disappearance percentages (IVDMD) were found. Part of these differences in IVDMD percentages were found to be associated with the presence or absence of polyphenolic compounds associated with the pigmented testa and pericarp of the mature grain sorghum caryopsis.

Phenotypic differences in polyphenol concentration were expressed in catechin equivalents (CE). Sorghum lines with CE concentrations below 1.00 did not affect IVDMD percentage. Genotypes containing CE concentrations above 1.00 had significantly reduced IVDMD percentages. IVDMD percentages were negatively correlated with CE concentrations ($r=-.623^{**}$).

Fourteen-day weanling rat weight gains from 172 sorghum selections were positively correlated with IVDMD percentages ($r=.484^{**}$) and negatively correlated with CE concentrations ($r=-.493^{**}$). However, when all grain sorghum selections were considered as a single group, at inherent crude protein concentrations and with varying CE concentrations, identification of genotypes having high nutritional quality by amino acid analyses was masked by the influence of factors associated with high CE concentrations in some of the pigmented sorghum selections. Thus, to relate the amino acid data to rat weight gains it is necessary to consider the low and high CE concentration groups independently.

Positive rat weight gain responses to lysine supplementation were obtained when rations made from low CE concentration selections were supplemented with lysine. Additional increases in weight gains were obtained by supplementing the rations made from low CE selections with three other essential amino acids (methionine, threonine and phenylalanine) when compared to lysine supplementation alone. Weight gains by rats fed rations supplemented with all four amino acids were in excess of 3g per day, indicating that the high leucine and arginine content in grain sorghum grains did not induce toxic effects for these short (14-day) feeding trials.

Rations from grain sorghum genotypes containing similar concentrations of crude protein and amino acid profiles, but containing CE concentrations greater than 1.00 produced significantly lower weanling rat weight gains than those obtained from the rations containing a low CE concentration. Supplementation with choline plus methionine of the ration from a sample containing a high CE concentration apparently corrected the adverse effects of high CE concentration since rat weight gains were similar to those of the ration having a low CE concentration. However, supplementation of rations from the genotypes having a high CE concentration with lysine alone or with lysine, methionine, threonine and phenylalanine combined, resulted in no significant increase in rat weight gain.

Partial removal of the pericarp and testa of the genotypes containing high CE concentrations lowered the measurable level of CE concentration. When rations containing dehulled grain were fed to weanling rats, weight gains were comparable to gains from rations with

low CE selections of similar crude protein and lysine content. Rations from dehulled high CE genotypes when supplemented with lysine resulted in improved feed efficiency ratios and weight gains increased to rates comparable with rations from genotypes with low CE concentrations.

Lysine was shown to be a limiting factor for weanling rat growth in grain sorghum by amino acid analyses. However, it was shown that lysine was not the most limiting factor in genotypes containing high CE concentrations. Therefore, genotypes containing high CE concentrations must be studied separately from genotypes containing low CE concentrations to identify amino acid deficiencies relative to nutritional quality. The chemical nature and activity of the factors associated with the pericarp and testa of genotypes containing high CE concentrations merits further investigation.

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APPENDICES

APPENDIX TABLE 1. FIELD AND LAB DATA FOR ALL GRAIN SORGHUM SAMPLES FED TO WEANLING RATS.(1)

IDENT SOURCE	PRO. C.E.	WT GAIN CHECK	IVDMD OIL	HT. FL.	HCL 100 S.W.	MG.P/S MG.L/S	PERI ENDO
001	11.9	4.45	73	195	4	2.73	5
954116	.38	78	3.14	69	2.25	.0520	7
002	11.8	2.90	80	180	2	3.32	1
954131	.42	51	3.18	77	2.46	.0648	6
003	12.4	3.70	50	255	5	2.49	3
IS1210	6.26	65	5.13	77	1.70	.0495	1
004	10.4	3.90	66	120	5	3.36	4
954054	.53	68	3.01	69	2.72	.0784	7
005	12.3	1.81	94	275	5	3.65	2
IS0062	.52	206	3.02	80	2.81	.0836	4
006	9.0	3.28	51	210	5	1.93	7
IS2283	6.88	57	3.00	81	1.88	.0376	3
007	14.3	7.63	87	215	4	3.05	2
IS0204	.44	133	4.02	74	1.95	.0628	6
008	11.8	5.73	80	280	2	3.64	1
IS2319	.51	100	4.43	80	3.27	.1001	6
009	10.3	8.08	88	205	4	1.85	5
IS1295	.46	216	2.17	75	1.64	.0360	3
010	13.2	2.27	84	230	3	3.43	8
IS0075	.97	61	3.20	75	2.74	.0629	4
011	11.4	4.98	79	120	1	2.59	2
954109	.21	133	3.56	69	2.17	.0492	8
012	11.8	4.63	83	095	2	2.28	2
954126	.14	124	2.56	84	1.90	.0632	5
013	12.0	2.82	90	190	2	4.64	2
IS0366	.33	75	3.05	71	3.83	.1252	5
014	9.5	.87	87	200	1	3.12	2
954065	.11	23	2.91	69	2.64	.0720	6

(1) See page 74 for identification of column headings.

APPENDIX TABLE 1. (CONTINUED).

IDENT SOURCE	PRO. C.E.	WT GAIN CHECK	IVDMD OIL	HT. FL.	HCL 100 S.W.	MG.P/S MG.L/S	PERI ENDO
015	9.8	.64	79	150	1	2.11	2
954062	.14	17	3.27	77	2.43	.0536	7
016	11.7	3.74	80	280	2	2.96	1
IS2319	.51	100	4.43	80	2.57	.0823	6
017	11.9	5.65	92	080	5	3.27	6
954004	.97	64	3.46	69	2.21	.0697	5
018	11.2	5.03	91	180	5	2.57	4
954156	.21	57	3.54	81	2.00	.0759	6
019	7.3	.93	59	245	5	1.54	9
IS2401	4.43	11	2.32	83	1.76	.0620	3
020	9.6	1.00	80	106	5	2.24	4
RX2349	.24	11	3.22	71	2.30	.0541	7
021	9.8	3.90	83	135	1	2.95	3
CX8168	.10	44	3.12	68	2.73	.0673	7
022	9.7	.45	56	209	4	3.92	2
CX0075	3.64	05	3.24	71	3.37	.0730	7
023	11.9	8.78	80	280	2	2.92	1
IS2319	.51	100	4.43	80	2.57	.0781	6
024	12.9	7.12	70	180	1	2.69	2
IS3129	.15	71	3.49	83	2.15	.0725	5
025	13.7	.72	80	165	2	3.89	3
IS3925	.01	107	3.05	79	2.74	.1165	7
026	13.7	8.28	89	330	2	3.23	2
IS4328	.41	82	3.05	92	2.19	.0901	5
027	12.6	3.75	63	180	5	3.94	4
IS0345	.53	37	3.05	67	3.03	.0682	5
028	14.4	8.30	88	220	5	3.92	5
IS0057	.27	83	3.49	72	2.55	.1104	6

APPENDIX TABLE 1. (CONTINUED).

IDENT SOURCE	PRO. C.E.	WT GAIN CHECK	IVDMD O	HT. FL.	HCL 100 S.W.	MG.P/S MG.L/S	PERI ENDO
029	10.3	2.17	76	240	1	2.57	6
IS6992	4.62	22	3.63	89	2.57	.0727	6
030	11.4	9.00	83	275	1	3.40	1
IS2288	.14	90	4.22	79	3.06	.0922	6
031	11.8	.05	80	280	2	2.86	1
IS2319	.51	100	4.43	80	2.57	.0766	6
032	10.0	4.13	85	200	3	1.65	2
IS3528	.53	81	2.63	87	1.73	.0470	5
033	9.1	3.35	72	200	1	2.53	2
IS0508	.18	65	2.78	79	2.61	.0695	6
034	11.3	6.00	87	270	4	4.76	8
IS6901	.59	117	3.72	87	3.61	.0925	6
035	7.8	1.03	73	150	3	1.19	6
IS0314	2.44	20	2.59	95	1.71	.0310	7
036	7.2	.42	84	200	1	2.06	1
IS0219	.01	09	3.03	80	2.60	.0371	7
037	9.0	1.98	82	235	1	1.86	2
IS9527	.20	39	2.88	83	2.07	.0415	7
038	8.9	1.95	49	210	5	2.10	7
IS2283	6.23	38	3.64	80	2.37	.0651	4
039	10.2	5.13	80	280	2	2.86	1
IS2319	.51	100	4.43	80	2.57	.0787	6
040	7.9	6.45	80	200	2	1.94	2
IS2549	.06	68	2.89	93	2.26	.0414	4
041	10.6	6.63	84	200	2	2.77	3
IS0508	.24	69	2.79	79	2.38	.0563	7
042	10.7	6.63	62	255	1	2.70	5
IS3485	2.97	69	2.81	101	2.44	.0517	4

APPENDIX TABLE 1. (CONTINUED).

IDENT SOURCE	PRO. C.E.	WT GAIN CHECK	IVDMD OIL	HT. FL.	HCL 100 S.W.	MG.P/S MG.L/S	PERI ENDO
043	11.7	6.98	87	295	1	3.59	4
IS2818	.16	178	3.10	94	2.80	.0736	3
044	10.8	4.12	58	255	5	2.17	3
IS1210	4.21	43	5.24	77	1.76	.0428	1
045	8.7	5.73	77	135	1	1.96	2
IS3982	.43	60	2.80	83	2.33	.0451	5
046	8.8	2.88	64	220	5	3.14	7
IS3401	4.30	30	2.75	90	2.15	.0536	2
047	11.1	9.55	80	280	2	2.70	1
IS2319	.51	100	4.43	80	2.57	.0447	6
048	8.4	.57	70	230	2	1.92	8
IS2709	.23	06	3.23	95	2.19	.0385	7
049	9.0	5.27	82	160	1	2.63	2
954062	.21	56	3.30	82	2.39	.0621	7
050	8.5	5.82	59	260	5	2.33	4
IS4225	2.46	62	4.37	84	2.65	.0612	3
051	8.4	1.02	46	180	4	1.63	5
IS0304	3.85	11	2.81	85	1.69	.0440	5
052	8.5	.92	73	150	5	1.40	5
IS0314	4.72	10	4.24	91	2.02	.0366	5
053	8.3	2.97	74	195	2	2.81	2
954104	.28	32	3.06	84	3.35	.0706	7
054	10.6	5.87	79	175	1	3.00	7
954164	.29	62	3.10	86	2.57	.0617	7
055	9.3	9.40	80	280	2	2.88	1
IS2319	.51	100	4.43	80	2.57	.0805	6
056	8.4	2.53	66	125	4	2.28	4
932198	.55	35	3.32	84	2.57	.0560	5

APPENDIX TABLE 1. (CONTINUED).

IDENT SOURCE	PRO. C.E.	WT GAIN CHECK	IVDMD OIL	HT. FL.	HCL 100 S.W.	MG.P/S MG.L/S	PERI ENDO
057	9.1	6.38	80	210	4	2.46	1
932033	.17	87	4.11	89	2.56	.0579	7
058	8.0	.42	37	140	2	2.14	7
IS7122	1.79	06	3.00	77	2.34	.0450	5
059	9.9	1.18	36	240	4	3.45	2
IS6881	6.69	16	3.32	87	3.27	.0739	5
060	8.7	1.73	50	165	4	1.99	4
932296	.62	24	3.69	83	2.21	.0394	7
061	8.7	2.88	78	165	5	1.73	4
954038	.52	39	3.12	84	1.76	.0498	5
062	8.1	2.13	44	230	5	2.29	7
IS3453	3.28	29	3.27	90	2.63	.0497	7
063	10.2	7.32	80	280	2	2.70	1
IS2319	.51	100	4.43	80	2.57	.0747	6
064	11.7	2.43	83	295	1	3.21	4
IS2818	.16	30	3.10	94	2.81	.0601	3
065	7.7	5.92	45	230	5	1.52	9
IS9198	7.60	74	3.82	101	1.90	.0433	4
066	7.0	.18	50	165	2	1.78	6
IS7822	1.79	02	2.49	81	2.19	.0404	5
067	9.3	2.32	46	200	5	2.06	6
IS0831	5.94	29	3.32	87	2.27	.0462	7
068	9.9	3.48	77	160	1	2.04	2
954130	.18	44	3.12	84	2.21	.0498	6
069	9.6	2.60	70	170	1	1.75	2
954136	.17	33	2.77	88	1.82	.0355	3
070	8.6	7.90	73	240	2	2.31	8
IS7579	.27	99	3.22	92	2.50	.0541	6

APPENDIX TABLE 1. (CONTINUED).

IDENT SOURCE	PRO. C.E.	WT GAIN CHECK	IVDMD OIL	HT. FL.	HCL 100 S.W.	MG.P/S MG.L/S	PERI ENDO
071	10.2	8.00	80	280	2	2.86	1
IS2319	.51	100	4.43	80	2.57	.0841	6
072	9.6	7.90	79	175	4	2.30	9
IS8295	.16	95	3.60	84	2.34	.0541	6
073	10.2	3.05	74	200	5	2.14	4
IS9457	.31	157	3.13	70	2.10	.0587	5
074	9.1	3.30	72	130	5	1.63	7
954242	.47	40	3.48	83	1.79	.0391	4
075	9.2	8.53	75	205	4	1.80	2
932152	.24	103	3.39	86	1.97	.0486	5
076	8.5	3.90	54	195	3	2.24	6
IS2848	1.00	47	2.78	83	2.49	.0525	5
077	8.5	5.40	79	230	2	2.61	2
IS3198	.15	65	3.31	92	2.55	.0544	7
078	9.4	5.75	58	230	5	2.88	7
IS9569	3.16	69	3.81	92	3.07	.0707	4
079	11.2	8.30	80	280	2	2.89	1
IS2319	.51	100	4.43	80	2.57	.0796	6
080	8.3	4.42	76	175	1	2.13	5
956036	1.32	48	2.28	83	2.45	.0544	3
081	8.5	8.27	63	160	1	2.51	1
954206	.21	90	3.35	86	2.70	.0604	4
082	8.3	6.82	74	165	4	1.60	4
IS1482	.73	74	3.14	84	2.02	.0468	7
083	9.8	7.60	61	195	1	3.30	2
954098	.25	83	3.30	88	3.24	.0809	5
084	9.6	5.50	69	185	1	2.12	2
954140	.74	60	2.36	87	2.15	.0466	5

APPENDIX TABLE 1. (CONTINUED).

IDENT SOURCE	PRO. C.E.	WT GAIN CHECK	IVDMD OIL	HT. FL.	HCL 100 S.W.	MG.P/S MG.L/S	PERI ENDO
085	8.8	6.73	58	245	5	2.82	7
932027	2.85	73	4.09	90	2.95	.0682	5
086	8.8	3.52	61	160	2	1.93	8
932075	.44	38	2.78	85	2.03	.0435	5
087	11.1	9.16	80	235	2	2.86	1
IS2319	.51	100	4.43	87	2.57	.0800	6
088	10.2	6.79	55	130	5	2.56	6
954255	3.35	55	2.91	84	2.42	.0491	4
089	8.4	9.68	70	165	1	2.19	3
954217	.39	78	2.90	82	2.64	.0562	5
090	8.6	9.00	81	140	1	2.80	2
954063	.23	73	2.80	77	2.44	.0737	7
091	9.1	5.40	65	225	5	2.86	7
932065	3.22	44	3.89	92	3.11	.0732	2
092	10.4	4.90	69	230	2	2.23	5
089034	.55	40	2.36	101	2.16	.0484	5
093	10.0	7.17	75	125	1	2.55	2
954114	.23	58	3.37	86	2.57	.0588	6
094	8.6	7.70	61	170	2	1.70	3
954239	.37	62	2.95	86	1.91	.0496	8
095	11.5	2.38	80	235	2	2.86	1
IS2319	.51	100	2.95	87	2.57	.0725	6
096	8.6	5.60	69	120	2	1.55	8
932145	.68	69	3.54	85	1.68	.0362	7
097	9.4	4.32	61	120	3	1.96	3
954248	.30	53	2.84	84	2.01	.0418	6
098	8.3	6.63	78	155	1	2.01	2
954145	.15	82	3.46	86	2.33	.0486	6

APPENDIX TABLE 1. (CONTINUED).

IDENT SOURCE	PRO. C.E.	WT GAIN CHECK	IVDMD OIL	HT. FL.	HCL 100 S.W.	MG.P/S MG.L/S	PERI ENDO
099	10.1	.22	84	175	5	2.90	3
954232	.35	126	2.46	77	2.73	.0652	7
100	8.9	5.67	74	210	1	2.37	2
954138	.25	70	3.02	84	2.23	.0532	6
101	11.1	5.70	63	175	1	3.60	8
954068	.40	70	3.34	85	3.31	.0769	7
102	9.9	5.05	77	230	4	2.85	4
954119	.98	62	3.20	77	2.70	.0552	7
103	11.1	8.13	80	235	2	3.02	1
IS2319	.52	100	4.43	87	2.57	.0698	6
104	10.2	5.38	78	175	1	3.75	2
954100	.28	57	3.24	84	3.55	.0768	7
105	9.3	1.93	52	130	2	2.19	6
932127	1.68	21	2.59	83	2.42	.0498	4
106	10.3	4.87	59	125	5	3.24	4
954052	.53	52	2.88	76	2.82	.0669	7
107	8.4	7.98	84	210	2	2.34	9
954071	.32	85	3.31	88	2.73	.0630	5
108	10.7	5.18	51	170	3	3.00	2
954076	.90	55	3.48	83	2.58	.0628	6
109	9.9	6.40	63	145	5	1.85	4
954167	.40	68	3.22	83	1.72	.0389	7
110	8.3	4.47	60	165	4	1.92	4
932175	.61	48	3.14	84	2.09	.0423	7
111	11.1	9.38	80	235	2	2.86	1
IS2319	.52	100	4.43	87	2.57	.0879	6
112	11.2	2.52	80	235	1	4.33	1
IS2319	.58	111	4.43	87	3.27	.0957	6

APPENDIX TABLE 1. (CONTINUED).

IDENT SOURCE	PRO. C.E.	WT GAIN CHECK	IVDMD OIL	HT. FL.	HCL 100 S.W.	MG.P/S. MG.L/S	PERI ENDO
113	9.3	4.22	65	205	5	2.55	6
IS6992	4.61	37	3.63	98	2.57	.0600	4
114	12.5	6.80	71	120	1	3.81	1
025035	.42	60	3.34	78	2.86	.0720	5
115	10.0	2.42	50	205	5	2.15	7
IS2942	5.70	21	3.26	81	2.12	.0439	4
116	12.6	.70	89	135	3	2.35	3
IS3982	.63	95	2.90	83	1.89	.0572	5
117	11.0	7.83	87	180	1	3.49	2
IS0219	.35	69	3.04	84	3.05	.0641	6
118	10.3	.83	88	185	3	2.19	2
IS2549	.63	96	2.89	84	2.26	.0602	6
119	11.5	1.32	80	235	2	2.86	1
IS2319	.58	100	4.43	87	2.57	.0883	6
120	12.5	.39	82	165	1	4.89	8
IS0075	1.40	04	2.78	77	3.69	.0846	4
121	12.5	.93	60	100	1	2.49	8
IS0129	.65	08	2.57	67	1.96	.0480	4
122	12.5	1.48	63	125	3	3.54	2
954111	.41	13	3.54	69	2.83	.0622	7
123	12.0	.60	78	115	5	2.01	4
954151	6.30	05	3.19	80	2.01	.0475	4
124	8.5	.53	57	155	2	2.70	5
IS3483	3.82	05	2.85	101	2.44	.0517	4
125	11.0	2.93	88	140	1	2.28	3
IS0508	.43	26	2.64	87	2.34	.0542	4
126	9.8	6.38	93	110	1	4.76	3
IS3935	.12	57	2.98	79	3.58	.1038	6

APPENDIX TABLE 1. (CONTINUED).

IDENT SOURCE	PRO. C.E.	WT GAIN CHECK	IVDMD OIL	HT. FL.	HCL 100 S.W.	MG.P/S MG.L/S	PERI ENDO
127	12.4	1.13	80	235	2	2.86	1
IS2319	.58	100	4.43	87	2.57	.0883	6
128	14.4	8.60	89	290	5	3.44	4
IS5083	.57	118	3.58		2.21	.0674	4
129	11.5	.95	91	280	5	4.81	4
IS2500	.16	70	3.39	93	3.93	.0983	4
130	12.4	8.45	76	115	5	3.72	4
954039	.51	54	3.35	77	3.01	.0667	7
131	9.9	4.73	50	190	5	2.42	6
MX3165	3.17	30	2.70		2.36	.0504	4
132	9.8	3.42	49	190	5	2.57	6
RX8165	5.22	22	2.76		2.51	.0533	4
133	11.7	4.95	61	155	2	2.78	3
954239	5.88	31	2.58	83	2.33	.0665	7
134	10.6	4.25	86	110	5	2.44	5
IS8165	5.16	27	2.94	96	2.39	.0577	5
136	10.0	.25	83	130	3	2.41	2
IS2939	1.13	65	2.95	87	2.25	.0542	4
137	9.9	5.28	61	160	2	3.86	2
IS0508	.09	34	2.78	96	3.61	.0876	6
138	11.5	5.75	80	230	2	2.86	1
IS2319	.58	100	4.43	80	2.81	.0749	6
139	11.8	9.03	85	180	1	3.22	2
954130	.26	49	3.31	82	2.48	.0671	6
140	10.2	6.65	71	110	3	1.79	6
IS8165	2.69	36	2.78	96	1.64	.0383	6
141	11.0	7.80	82	155	2	3.10	2
IS0175	.53	43	3.16	85	2.53	.0449	7

APPENDIX TABLE 1. (CONTINUED).

IDENT SOURCE	PRO. C.E.	WT GAIN CHECK	IVDMD OIL	HT. FL.	HCL 100 S.W.	MG.P/S MG.L/S	PERI ENDO
142	12.1	1.17	65	220	2	4.13	2
954179	.32	61	2.63	69	3.34	.0772	7
143	13.5	.27	67	120	2	3.35	8
IS3687	1.47	56	3.34	80	2.39	.0676	6
144	10.1	5.08	58	135	4	2.38	6
RS690	6.20	28	3.22	72	2.25	.0538	4
145	9.9	8.62	75	155	5	2.35	5
RS671	.37	47	3.08	72	2.16	.0457	4
146	9.3	1.97	54	160	5	1.88	7
BR64	8.10	11	3.11	74	2.06	.0446	5
147	9.9	8.07	64	155	4	2.57	5
RS610	.48	44	3.20	66	2.42	.0566	5
148	9.9	6.47	58	215	5	2.25	5
NK300	4.01	35	3.10	76	2.13	.0505	4
149	12.1	8.35	80	280	2	2.86	1
IS2319	.58	100	4.75	80	2.57	.0646	6
150	10.9	7.27	67	120	5	2.84	4
640072	.58	49	3.20	74	2.64	.0662	4
151	12.0	4.63	61	110	1	2.77	2
954021	.81	31	2.18	61	2.42	.0677	5
152	8.5	4.65	50	220	5	1.84	7
IS8260	8.10	31	3.23	97	2.26	.0638	3
153	9.8	4.05	71	185	3	2.40	2
IS3568	.15	27	3.10	90	2.34	.0431	4
154	12.5	1.98	79	210	1	3.05	8
IS0075	1.45	13	2.78	83	2.36	.0610	4
155	10.7	6.08	70	120	2	1.72	8
IS0104	.54	41	1.93	78	1.60	.0408	3

APPENDIX TABLE 1. (CONTINUED).

IDENT SOURCE	PRO. C.E.	WT GAIN CHECK	IVDMD OIL	HT. FL.	HCL 100 S.W.	MG.P/S MG.L/S	PERI ENDO
156	11.2	4.38	72	220	3	2.90	9
IS7193	.20	29	2.58	99	2.61	.0731	4
157	9.9	6.58	64	155	4	3.06	5
RS610	.48	43	3.20	66	2.88	.0674	5
158	12.0	2.67	67	120	5	4.39	8
IS3687	.16	47	3.34	80	3.58	.0873	6
159	12.6	.87	83	110	5	2.45	4
IS3979	1.20	15	2.66	87	1.84	.0438	6
160	10.9	4.05	67	120	5	2.81	4
640072	.68	72	3.20	74	2.64	.0587	5
161	11.1	.68	89	120	5	3.10	4
222G	.67	12	2.88	74	2.67	.0584	7
162	11.6	2.68	72	125	2	2.95	2
954066	.45	48	2.77	69	2.43	.0674	6
163	10.7	1.73	70	120	2	1.50	9
IS0104	.63	31	2.77	78	1.42	.0307	4
164	10.1	2.73	63	150	2	2.28	2
IS0345	.53	48	3.05	68	2.21	.0457	7
165	9.9	2.48	64	155	4	2.81	5
RS610	.48	44	3.20	66	2.42	.0621	5
166	13.5	5.72	64	120	2	2.71	8
IS3687	.17	56	3.34	80	1.97	.0471	7
167	12.0	2.78	67	120	5	4.39	4
IS3687	1.47	27	3.34	80	3.58	.0873	7
168	14.1	3.10	78	125	2	4.50	2
FK-766	.10	31	3.00	75	3.43	.0906	6
169	8.5	3.80	48	220	5	1.84	7
IS8260	8.10	38	3.23	97	2.26	.0638	3

APPENDIX TABLE 1. (CONTINUED).

IDENT SOURCE	PRO. C.E.	WT GAIN CHECK	IVDMD OIL	HT. FL.	HCL 100 S.W.	MG.P/S MG.L/S	PERI ENDO
170	12.1	.13	80	230	2	2.86	1
IS2319	.68	100	4.49	80	2.57	.0906	6
171	9.3	1.12	30	160	5	1.85	6
BR64	8.10	11	3.11	74	2.06	.0426	7
172	11.2	2.60	72	220	3	2.79	5
IS7193	.25	27	2.58	99	2.51	.0703	5
173	9.9	2.58	64	155	4	2.81	5
RS610	.48	25	3.20	66	2.42	.0612	5

(1)

Ident = Sample Number
Source = Purdue Base Number

Pro. = % Protein
C.E. = Catechin Equivalent (%)

Wt Gain = g/Rat/14 Days
Check = Sample Weight Gain ÷ Sample 2319 Weight Gain x 100

IVDMD = In Vitro Dry Matter Disappearance (%)
Oil = % Oil

Ht. = Height in cm
Fl. = Days to 50% Bloom

HCL = Anthocyanogen Test:
1 clear, 2 yellow, 3 magenta, 4 red, 5 darker red
100 S.W. = g/100 Seeds

MG.P/S = Milograms Protein/Seed
MG.L/S = Milograms Lysine/ Seed

Peri = Pericarp Color:
1 white, 2 straw, 3 yellow, 4 orange, 5 lt. brown, 6 brown, 7 red brown, 8 gray, 9 purple
Endo = Endosperm:
3 floury, 5 normal, 7 corneous

APPENDIX TABLE 2. PROTEIN AND AMINO ACID DATA FOR ALL SAMPLES FED TO WEANLING RATS.(1)

I.D. SOURCE I.S.	PROT. LYS. PXL.	MET. CYS. M+C.	LEU. ISO. I/L.	HIS. ARG. THR.	ALA. TYR. PHE.	GLU. PRO. ASP.	SER. GLY. VAL.
001	12.12	.50	15.55	2.03	10.09	26.24	4.99
954116	1.90	.99	4.24	4.08	4.49	7.56	3.30
	23.10	1.49	.273	3.51	5.48	7.79	5.55
002	13.50	1.32	15.65	1.76	10.38	33.48	4.50
954131	1.95	.61	4.36	2.12	4.75	8.71	3.02
	26.35	1.93	.279	3.36	5.95	7.66	5.52
003	14.62	.82	14.80	1.98	10.40	23.59	5.19
925060	1.99	1.01	3.90	3.74	4.64	8.52	3.02
1210	29.10	1.83	.263	3.41	5.20	8.17	5.22
004	12.37	1.17	16.07	2.19	10.38	26.85	4.80
954054	2.33	1.21	4.47	3.73	5.12	7.61	3.47
	28.82	2.38	.278	3.56	5.71	8.23	6.05
005	13.00	1.16	13.58	1.79	9.11	23.40	4.24
925006	2.29	1.16	3.71	4.11	4.35	6.01	3.24
0062	29.74	2.32	.273	3.13	4.69	7.98	5.19
006	10.25	1.18	13.49	1.40	8.98	23.52	2.80
925074	1.95	.31	3.91	3.41	3.09	6.27	2.87
2283	20.00	1.49	.290	2.26	4.27	5.38	4.97
007	15.63	1.28	14.89	1.87	10.24	23.02	5.07
925018	2.06	.87	3.92	3.44	4.47	8.57	3.10
0204	32.21	2.15	.263	3.30	4.98	7.52	5.04
008	11.12	1.83	13.84	2.41	10.06	22.62	4.60
	2.75	1.41	4.15	4.90	4.96	7.82	3.61
2319	30.62	3.25	.300	3.37	5.73	7.45	5.50
009	11.25	1.21	12.88	1.68	8.94	21.25	4.27
917025	1.95	.55	3.68	3.70	3.85	8.24	2.99
1295	21.94	1.75	.286	3.01	4.35	6.96	4.87
010	12.50	.50	16.50	1.70	12.23	38.68	4.83
	1.84	.29	4.38	3.32	4.94	8.06	2.84
0075	22.94	.79	.266	2.93	5.73	8.56	5.98
011	11.94	1.04	16.67	2.01	10.66	27.42	4.98
954109	1.90	1.16	4.40	3.84	5.04	8.16	3.33
	22.66	2.21	.264	3.53	5.87	7.90	5.92

(1) See page 90 for identification of column headings.

APPENDIX TABLE 2. (CONTINUED).

I.D. SOURCE I.S.	PROT. LYS. PXL.	MET. CYS. M+C.	LEU. ISO. I/L.	HIS. ARG. THR.	ALA. TYR. PHE.	GLU. PRO. ASP.	SER. GLY. VAL.
012	12.00	.25	13.57	1.89	10.25	32.49	3.81
954125	2.77	.53	4.25	4.04	4.09	6.57	3.56
	33.24	.78	.313	3.27	4.70	8.79	5.58
013	12.12	.31	14.14	2.02	10.56	33.81	5.10
	2.70	.91	4.40	4.60	4.53	8.38	3.68
0366	32.71	1.21	.311	3.66	4.66	9.18	5.74
014	11.81	.62	14.58	2.02	9.47	24.77	4.62
954065	2.31	.98	4.06	4.30	4.60	7.06	3.26
	27.26	1.60	.279	3.34	5.22	8.23	5.41
015	8.69	1.89	14.13	2.31	9.90	21.66	4.51
954062	2.54	1.34	4.12	4.45	4.63	8.03	3.42
	22.07	3.23	.291	3.13	5.58	7.24	5.10
016	11.50	1.82	13.76	2.49	9.88	22.26	4.64
	2.78	1.42	4.15	4.85	4.75	7.96	3.66
2319	32.02	3.24	.302	3.38	5.50	7.42	5.46
017	14.81	.23	13.26	1.73	8.76	19.37	3.61
954004	2.13	.57	3.79	3.35	3.96	7.28	2.73
	31.53	.80	.286	2.83	4.37	7.91	4.88
018	12.87	1.02	13.95	1.86	9.80	20.98	3.79
954156	2.95	.54	4.07	4.23	3.75	6.94	3.68
	37.93	1.56	.292	3.06	4.65	7.63	5.53
019	8.75	.81	12.35	2.30	8.54	18.63	4.74
925080	4.02	1.17	4.12	5.79	4.35	6.27	4.17
	35.22	1.98	.334	4.05	4.52	9.79	5.60
020	9.75	.29	14.95	2.41	9.60	21.72	4.69
029144	2.41	1.36	4.17	4.10	4.57	7.79	3.30
	23.51	1.65	.279	3.53	4.96	8.74	5.33
021	10.81	.06	14.43	2.15	9.25	21.06	4.41
029041	2.28	1.42	4.05	3.92	4.48	6.54	3.25
	24.66	1.48	.281	3.46	4.77	8.77	5.21
022	11.62	.16	15.67	1.92	9.85	22.64	4.24
	1.86	1.12	4.17	3.49	4.40	8.64	2.71
0075	21.65	1.28	.266	3.24	5.10	8.33	5.15

APPENDIX TABLE 2. (CONTINUED).

I.D. SOURCE I.S.	PROT. LYS. PXL.	MET. CYS. M+C.	LEU. ISO. I/L.	HIS. ARG. THR.	ALA. TYR. PHE.	GLU. PRO. ASP.	SER. GLY. VAL.
023	11.25	1.82	13.86	2.44	10.03	22.58	4.65
	2.75	1.42	4.17	4.86	4.74	7.99	3.66
2319	30.99	3.24	.301	3.39	5.51	7.48	5.52
024	12.50	1.19	15.02	1.93	9.72	22.28	4.58
	2.70	.92	4.32	4.21	4.65	7.52	3.36
3129	33.72	2.11	.288	3.28	5.03	8.11	5.18
025	14.19	1.37	14.61	2.48	9.62	21.95	4.94
	3.00	1.14	4.16	4.78	4.68	9.32	3.58
3925	42.52	2.52	.285	3.82	5.24	8.47	5.46
026	14.75	1.18	14.32	1.91	9.27	21.02	4.76
	2.79	1.24	4.01	[illegible].47	4.59	8.75	3.37
4328	41.13	2.42	.280	3.62	4.90	8.43	5.09
027	13.00	.97	13.84	1.60	8.69	19.69	4.06
	1.73	.77	3.72	3.13	4.27	6.91	2.54
0345	22.51	1.74	.269	3.04	4.45	6.51	4.49
028	15.37	.75	11.59	1.70	7.85	17.20	4.07
	2.82	.89	3.48	4.25	3.85	5.48	3.29
0057	43.31	1.65	.300	3.21	4.12	7.52	4.61
029	10.00	1.09	13.64	1.78	9.48	20.81	3.77
	2.83	.33	3.93	4.50	3.82	8.24	3.45
5992	28.27	1.42	.288	3.07	4.38	7.81	5.23
030	11.12	.95	14.63	1.97	9.46	21.36	4.62
	2.71	.94	4.04	4.66	4.66	7.29	3.28
2288	30.12	1.89	.276	3.47	4.93	8.54	5.14
031	11.12	1.75	13.59	2.43	9.66	21.40	4.45
	2.68	1.33	4.03	4.92	4.84	7.22	3.45
2319	29.80	3.08	.297	3.29	4.91	7.19	5.33
032	9.56	1.30	12.89	2.03	9.26	19.69	4.58
	2.84	1.06	4.07	4.14	4.40	7.13	3.36
3528	27.[illegible]	2.36	.316	3.34	5.28	7.90	5.06
033	9.69	1.03	14.90	2.64	10.53	22.99	5.03
	2.75	1.44	4.52	4.51	15.04	8.80	3.95
0508	26.62	2.47	.303	3.56	6.04	8.44	5.74

APPENDIX TABLE 2. (CONTINUED).

I.D. SOURCE I.S.	PROT. LYS. PXL.	MET. CYS. M+C.	LEU. ISO. I/L.	HIS. ARG. THR.	ALA. TYR. PHE.	GLU. PRO. ASP.	SER. GLY. VAL.
034	11.62	1.51	13.20	2.29	9.25	21.44	4.35
	2.03	1.14	3.86	3.68	4.50	7.56	3.07
0508	23.64	2.65	.292	3.00	5.46	6.39	4.78
035	6.94	1.78	12.86	2.26	9.26	21.08	4.34
	2.61	1.26	3.83	4.24	4.60	6.61	3.35
0314	18.11	3.04	.298	3.17	5.39	7.10	4.90
036	7.94	.58	16.71	2.59	11.67	25.49	5.10
	1.80	1.54	4.53	3.74	5.44	9.52	3.37
0219	14.26	2.13	.271	3.49	6.39	8.32	5.68
037	9.00	0.47	15.11	2.39	10.73	24.04	4.92
	2.23	1.68	4.43	3.95	4.85	8.49	3.44
9527	20.06	1.21	.293	3.44	5.57	8.48	5.53
038	9.25	.61	12.14	2.57	9.02	19.09	4.72
	2.97	1.26	3.85	4.89	4.13	7.48	3.96
2283	27.45	1.87	.317	3.32	5.03	8.17	5.17
039	12.50	.71	14.06	2.19	9.49	20.49	4.42
	2.81	1.13	4.09	4.96	4.58	6.80	3.48
2319	35.10	1.84	.291	3.49	4.89	7.89	5.42
040	8.56	1.65	13.79	2.21	9.52	21.92	4.15
	2.14	1.05	4.17	3.70	4.52	7.64	3.10
2549	18.32	2.70	.302	3.02	5.52	6.61	5.03
041	10.69	1.59	13.97	2.27	9.66	22.77	4.38
	2.27	1.54	4.13	4.23	4.74	8.27	2.83
0508	24.27	3.13	.296	3.23	5.11	6.96	5.05
042	11.06	1.31	14.19	2.10	9.73	22.70	4.25
	1.92	1.27	4.13	4.46	4.78	8.19	2.78
3485	21.19	2.58	.291	2.95	5.11	6.85	4.85
043	12.81	1.75	12.75	2.07	9.25	21.28	4.15
	2.05	1.35	3.72	3.67	4.44	7.23	2.88
2818	26.28	3.11	.292	2.93	5.05	6.63	4.73
044	12.31	1.85	13.71	2.33	9.81	22.94	4.28
	1.97	1.22	3.85	4.06	4.53	7.95	2.89
1210	24.30	3.07	.281	2.99	5.29	6.72	4.82

APPENDIX TABLE 2. (CONTINUED).

I.D. SOURCE I.S.	PROT. LYS. PXL.	MET. CYS. M+C.	LEU. ISO. I/L.	HIS. ARG. THR.	ALA. TYR. PHE.	GLU. PRO. ASP.	SER. GLY. VAL.
045	8.38	1.72	13.67	2.38	9.46	21.81	4.41
	2.31	1.24	4.06	3.95	4.47	7.51	3.38
3982	19.34	2.96	.297	3.23	5.57	6.59	4.99
046	14.62	1.31	16.67	2.04	11.06	26.60	4.39
	1.71	1.28	4.47	3.69	4.95	9.40	2.71
3401	24.95	2.59	.268	3.06	6.03	7.27	5.30
047	12.50	.71	14.06	2.19	9.49	20.49	4.42
	2.81	1.13	4.09	4.96	4.58	6.80	3.48
2319	35.10	1.84	.291	3.49	4.89	7.89	5.42
048	8.75	1.55	13.86	2.33	9.52	22.39	4.34
	2.01	1.43	3.91	3.97	4.65	7.29	3.10
2709	17.59	2.98	.282	2.97	5.60	6.35	4.76
049	11.00	1.03	15.08	2.06	9.79	25.70	4.71
954062	2.36	1.08	4.22	.00	4.76	7.36	3.48
	25.98	2.11	.280	3.47	5.44	8.01	5.55
050	8.81	1.93	13.43	2.52	9.81	22.75	4.61
	2.62	1.36	3.94	4.84	4.94	7.37	3.58
4225	23.11	3.29	.294	3.29	5.61	7.42	5.13
051	9.62	2.04	12.84	2.53	9.35	21.64	4.55
	2.71	1.42	3.84	5.03	4.51	7.24	3.67
0304	26.06	3.46	.299	3.29	5.17	6.91	5.03
052	6.94	1.78	12.86	2.26	9.26	21.08	4.34
	2.61	1.26	3.83	4.24	4.60	6.61	3.35
0314	18.11	3.04	.298	3.17	5.39	7.10	4.90
053	8.38	1.85	14.86	2.55	10.45	23.84	4.96
954104	2.52	1.33	4.35	4.54	4.68	8.39	3.63
	21.08	3.18	.292	3.55	5.50	7.26	5.47
054	11.69	1.49	14.50	2.02	10.12	23.28	4.66
954164	2.05	1.13	4.20	3.87	4.40	8.09	3.10
	24.02	2.62	.289	3.14	5.54	7.27	5.01
055	11.19	.68	14.09	2.17	9.36	20.90	4.52
	2.80	1.13	4.09	4.92	4.56	6.82	3.51
2319	31.33	1.81	.290	3.59	4.89	8.44	5.43

APPENDIX TABLE 2. (CONTINUED).

I.D. SOURCE I.S.	PROT. LYS. PXL.	MET. CYS. M+C.	LEU. ISO. I/L.	HIS. ARG. THR.	ALA. TYR. PHE.	GLU. PRO. ASP.	SER. GLY. VAL.
056	8.88	1.83	12.99	2.53	8.89	21.41	4.15
932198	2.46	1.51	3.85	3.99	4.25	7.34	3.20
	21.80	3.34	.281	3.07	5.60	6.56	4.83
057	9.62	1.85	14.12	2.34	9.51	22.62	4.44
932033	2.35	1.52	4.19	4.52	4.59	8.11	3.13
	22.61	3.37	.296	3.22	6.15	6.74	5.04
058	9.13	1.80	13.43	2.31	9.10	21.52	4.19
	2.11	1.58	3.87	4.13	4.45	7.50	3.17
7122	19.23	3.38	.288	3.11	5.77	6.58	4.89
059	10.56	1.68	13.94	2.10	9.44	22.43	4.26
	2.14	1.34	3.99	4.22	4.50	7.83	3.03
6881	22.60	3.02	.286	3.12	5.81	7.01	5.03
060	9.00	1.70	13.44	2.10	9.27	21.83	4.16
932296	1.98	1.47	3.84	3.80	4.60	7.47	2.94
	17.81	3.17	.286	3.08	5.11	6.46	4.82
061	9.06	1.18	14.02	2.40	9.37	22.18	4.37
954038	2.23	1.39	4.13	3.80	4.41	7.79	3.08
	20.20	2.57	.295	3.17	6.24	7.20	4.96
062	8.69	1.63	13.41	2.19	9.14	21.32	4.16
	2.18	1.36	3.86	3.82	4.27	7.04	3.12
3453	18.91	2.98	.288	3.06	5.58	6.52	4.81
063	10.50	1.84	13.97	2.39	9.98	22.95	4.57
	2.77	1.43	4.06	4.74	4.98	7.12	3.44
2319	29.05	3.26	.291	3.37	5.74	7.46	5.24
064	11.44	.09	13.33	2.22	9.37	20.14	5.10
925098	4.12	1.38	4.46	5.75	2.83	8.72	4.26
	47.08	1.47	.335	4.37	4.74	11.40	5.91
065	8.00	1.75	12.43	2.23	3.67	19.63	4.30
	2.85	1.24	3.94	4.17	5.06	6.61	3.35
9198	22.81	2.99	.317	3.19	5.65	7.34	4.90
066	8.12	1.66	12.96	2.25	8.85	20.80	4.09
	2.27	1.31	3.84	3.94	4.19	6.84	3.12
7822	18.43	2.98	.296	2.99	5.61	6.46	4.75

APPENDIX TABLE 2. (CONTINUED).

I.D. SOURCE I.S.	PROT. LYS. PXL.	MET. CYS. M+C.	LEU. ISO. I/L.	HIS. ARG. THR.	ALA. TYR. PHE.	GLU. PRO. ASP.	SER. GLY. VAL.
067	9.06	1.61	14.46	2.19	9.84	23.22	4.38
	2.25	1.32	4.13	4.14	4.51	7.14	3.01
0831	20.35	2.93	.286	3.10	6.14	7.21	5.00
068	9.25	1.68	12.67	2.03	8.68	20.00	4.15
954130	2.43	1.29	3.94	3.88	4.29	6.82	3.12
	22.52	2.97	.311	3.04	5.91	6.69	4.69
069	9.62	1.58	13.96	1.84	9.38	22.03	3.96
954136	2.03	1.14	4.10	3.46	4.41	6.81	2.75
	19.51	2.72	.294	2.91	6.04	6.64	4.87
070	9.25	1.66	12.49	1.95	8.54	19.85	3.97
	2.34	1.37	3.73	4.07	4.23	6.34	3.02
7579	21.63	3.06	.299	2.96	5.43	7.04	4.75
071	11.12	1.93	13.95	2.70	9.65	23.51	4.65
	2.94	1.45	4.22	5.64	4.76	7.42	3.71
2319	32.71	3.39	.302	3.52	5.39	7.40	5.53
072	9.81	1.81	14.42	2.31	9.98	23.29	4.67
	2.35	1.29	4.24	4.13	4.82	8.01	3.38
8295	23.10	3.10	.294	3.25	5.75	7.37	5.26
073	10.19	1.98	13.68	2.56	10.16	23.64	4.67
	2.74	1.17	4.32	4.55	4.87	8.45	3.67
9457	27.96	3.15	.316	3.44	5.53	7.53	5.63
074	9.13	1.71	14.58	2.49	10.31	23.70	4.75
	2.40	1.15	4.29	4.47	4.68	8.56	3.49
2133	21.86	2.86	.294	3.45	5.50	7.38	5.45
075	9.31	1.92	15.17	2.32	10.40	23.93	4.88
932152	2.65	1.14	4.56	4.36	4.88	8.74	3.59
	24.65	3.06	.301	3.51	5.97	7.75	5.56
076	9.00	1.81	13.81	2.33	9.52	22.07	4.50
	2.34	1.15	4.09	4.30	4.77	7.80	3.37
2848	21.08	2.96	.297	3.18	5.68	6.89	5.06
077	10.25	1.76	14.44	2.23	10.25	23.56	4.46
	2.08	1.12	4.24	4.11	4.94	8.26	3.37
3198	21.32	2.88	.294	3.23	5.82	6.91	5.36

APPENDIX TABLE 2 (CONTINUED).

I.D. SOURCE I.S.	PROT. LYS. PXL.	MET. CYS. M+C.	LEU. ISO. I/L.	HIS. ARG. THR.	ALA. TYR. PHE.	GLU. PRO. ASP.	SER. GLY. VAL.
078	9.38	1.72	14.42	2.45	9.97	23.15	4.69
	2.46	1.22	4.23	4.42	5.03	8.12	3.49
9569	23.03	2.94	.293	3.39	5.88	7.42	5.39
079	11.12	1.96	13.76	2.50	9.53	23.19	4.58
	2.76	1.45	4.06	4.93	4.69	6.88	3.66
2319	30.67	3.41	.295	3.47	13.44	7.49	5.44
080	8.69	1.94	14.21	2.31	9.88	22.90	4.67
956036	2.56	1.40	4.27	4.43	4.80	7.98	3.62
	22.22	3.34	.300	3.42	5.71	7.20	5.34
081	9.31	1.71	12.68	2.16	8.73	19.99	4.14
954206	2.40	1.41	3.85	4.38	4.51	7.41	3.25
	22.37	3.11	.303	3.03	4.96	6.63	4.77
082	9.19	1.53	12.18	2.15	8.52	19.60	4.04
932175	2.20	1.35	3.66	3.60	4.00	7.17	3.03
	20.24	2.88	.300	2.90	4.89	6.27	4.60
083	10.19	1.86	15.88	2.41	10.03	25.25	4.91
954098	2.45	1.40	4.60	4.44	5.34	8.71	3.49
	24.98	3.26	.289	3.54	6.50	7.49	5.57
084	9.87	1.84	16.02	2.23	11.30	25.79	4.73
954140	2.20	1.16	4.61	3.99	5.20	8.39	3.33
	21.68	3.00	.288	3.37	6.20	7.42	5.72
085	9.56	1.73	13.32	2.36	9.28	21.56	4.41
932027	2.42	1.24	4.02	4.19	4.47	7.87	3.43
	23.13	2.97	.302	3.26	5.21	7.04	5.21
086	9.50	1.78	14.16	2.15	9.72	22.35	4.44
932075	2.25	1.50	4.21	3.98	4.80	8.21	3.25
	21.41	3.28	.298	3.10	5.81	6.56	5.15
087	11.12	.58	13.86	2.17	10.18	22.89	4.30
	2.80	1.29	4.00	4.69	4.59	6.65	3.74
2319	31.11	1.88	.289	3.31	5.18	8.72	5.65
088	10.56	1.95	15.05	2.14	10.75	24.79	4.92
954255	1.92	1.38	4.38	3.75	5.32	8.83	3.40
	20.27	3.33	.291	3.40	6.23	6.92	5.38

APPENDIX TABLE 2. (CONTINUED).

I.D. SOURCE I.S.	PROT. LYS. PXL.	MET. CYS. M+C.	LEU. ISO. I/L.	HIS. ARG. THR.	ALA. TYR. PHE.	GLU. PRO. ASP.	SER. GLY. VAL.
089	8.88	1.50	14.55	2.73	9.91	23.56	4.89
954217	2.59	1.69	4.41	4.36	4.99	8.57	3.76
	23.03	3.19	.303	3.55	6.14	7.48	5.51
090	9.00	1.90	13.74	2.36	9.47	22.07	4.45
954063	2.63	1.59	4.23	4.37	4.63	7.79	3.62
	23.69	3.49	.308	3.31	5.61	7.04	5.37
091	9.19	1.71	13.77	2.48	9.55	22.25	4.65
932065	2.56	1.36	4.13	4.49	4.89	7.87	3.63
	23.53	3.07	.300	3.41	5.67	7.40	5.34
092	10.31	1.73	14.37	2.36	10.11	23.69	4.73
089034	2.17	1.25	4.27	3.77	4.68	8.19	3.28
	22.41	2.39	.298	3.24	5.73	6.88	5.11
093	9.94	1.63	14.43	2.38	9.93	23.05	4.47
954114	2.30	1.38	4.29	4.19	4.60	8.46	3.41
	22.86	3.01	.297	3.27	5.51	6.89	5.33
094	8.88	2.19	15.12	2.66	10.49	24.10	5.09
954239	2.93	1.70	4.66	5.18	5.34	8.47	4.11
	25.99	3.89	.308	3.80	6.42	7.82	5.87
095	11.12	.87	14.05	1.88	9.69	28.47	4.45
	2.54	1.01	4.05	4.38	4.38	6.26	3.40
2319	28.22	1.88	.288	3.30	4.64	7.96	5.48
096	9.25	1.90	14.01	2.43	9.75	22.70	4.57
932145	2.33	1.55	4.19	4.23	4.99	8.02	3.48
	21.56	3.45	.299	3.28	5.95	6.78	5.19
097	9.75	1.91	15.82	2.32	10.90	25.19	4.85
954248	2.13	1.41	4.54	4.23	5.39	8.92	3.39
	20.79	3.32	.287	3.38	6.55	7.20	5.47
098	8.63	1.56	13.37	2.27	8.94	21.52	4.32
954145	2.42	1.44	4.05	4.02	4.47	7.47	3.16
	20.87	3.00	.308	3.17	5.47	6.94	4.94
099	10.63	1.91	14.84	2.52	10.07	23.65	4.57
954232	2.25	1.36	4.53	4.05	5.21	8.95	3.52
	23.87	3.28	.305	3.36	6.43	7.15	5.35

APPENDIX TABLE 2. (CONTINUED).

I.D. SOURCE I.S.	PROT. LYS. PXL.	MET. CYS. M+C.	LEU. ISO. I/L.	HIS. ARG. THR.	ALA. TYR. PHE.	GLU. PRO. ASP.	SER. GLY. VAL.
100	9.94	1.40	13.36	2.22	9.11	21.56	4.12
954138	2.28	1.22	3.92	3.91	4.29	7.22	2.98
	22.62	2.62	.294	3.03	5.63	6.79	4.91
101	10.87	1.66	13.45	2.21	9.51	22.20	4.24
954068	2.14	1.52	3.94	4.07	4.69	7.44	3.19
	23.23	3.18	.293	3.10	5.43	6.59	5.06
102	10.56	1.79	15.91	2.27	11.12	25.62	4.68
954119	1.94	1.50	4.47	3.67	5.01	8.72	3.03
	20.44	3.29	.281	3.28	6.04	7.10	5.47
103	11.75	.98	12.96	1.66	8.92	25.88	4.45
	2.31	.40	3.82	4.03	4.16	8.10	3.18
2319	27.15	1.37	.295	2.98	4.35	6.93	5.30
104	10.56	1.73	14.31	2.00	9.83	23.02	4.16
954100	2.05	1.43	4.27	3.80	4.86	8.09	3.21
	21.64	3.16	.299	3.13	5.85	6.76	5.26
105	9.06	1.80	14.50	2.23	10.00	23.20	4.57
932127	2.27	1.42	4.31	4.29	4.75	8.11	3.50
	20.56	3.22	.297	3.29	5.83	7.06	5.33
106	11.50	1.63	13.53	2.11	9.28	21.72	4.22
954052	2.06	1.23	4.10	3.80	4.58	7.85	3.31
	23.71	2.87	.303	3.14	5.40	6.64	5.10
107	8.56	1.67	13.80	2.62	9.72	22.68	4.37
954071	2.70	1.43	4.26	4.57	4.62	7.87	3.61
	23.09	3.10	.309	3.42	5.47	7.10	5.54
108	11.62	1.52	13.61	2.19	9.60	22.18	4.30
954076	2.09	1.26	3.99	3.99	4.43	7.86	3.11
	24.33	2.78	.293	3.04	5.33	6.80	5.02
109	10.75	1.64	14.43	2.28	9.95	23.48	4.31
954167	2.10	1.29	4.30	3.76	4.74	7.91	3.15
	22.63	2.93	.298	3.04	6.10	6.78	5.21
110	7.94	1.71	14.24	2.70	10.04	23.04	4.67
	2.92	1.49	4.43	5.08	4.58	8.13	3.79
1482	23.18	3.20	.311	3.51	5.61	7.67	5.61

APPENDIX TABLE 2. (CONTINUED).

I.D. SOURCE I.S.	PROT. LYS. PXL.	MET. CYS. M+C.	LEU. ISO. I/L.	HIS. ARG. THR.	ALA. TYR. PHE.	GLU. PRO. ASP.	SER. GLY. VAL.
111	11.12	1.04	15.40	2.29	10.50	24.33	5.47
	3.08	.97	4.33	4.84	5.09	9.29	4.22
2319	34.21	2.01	.281	3.99	5.67	9.11	5.99
112	13.25	1.66	12.84	2.02	8.82	20.82	3.95
	2.21	1.22	3.75	3.99	4.34	6.44	2.96
2319	29.28	2.88	.202	2.98	5.51	6.68	4.82
113	9.94	1.46	12.68	2.21	8.74	20.47	4.06
	2.35	1.44	3.84	4.71	4.30	7.19	3.16
6992	23.34	2.90	.303	3.03	4.35	6.78	4.86
114	13.31	1.64	14.35	2.25	9.65	22.89	4.10
025035	1.89	1.50	4.04	3.45	4.45	6.54	2.83
	25.19	3.14	.281	2.94	5.39	6.26	4.84
115	10.12	1.68	14.04	2.15	9.57	22.67	4.32
	2.04	1.51	4.03	3.85	4.67	8.12	3.05
2942	20.70	3.19	.287	3.05	5.02	6.66	4.92
116	12.44	1.99	13.52	2.45	9.42	22.41	4.21
	2.44	1.76	4.08	4.42	4.83	8.42	3.38
3982	30.29	3.75	.302	3.30	4.92	6.81	5.36
117	11.44	1.73	15.26	2.47	10.57	24.93	4.22
	1.84	1.66	4.26	4.02	5.09	8.48	2.97
0219	21.03	3.39	.279	3.07	5.20	6.73	5.31
118	7.37	1.10	14.49	1.98	10.03	22.85	4.34
	2.53	.35	4.19	4.10	3.99	4.78	3.54
2549	18.69	1.45	.289	3.27	5.03	7.28	5.47
119	11.12	1.29	14.04	2.65	9.14	19.71	4.64
	3.09	1.44	4.36	5.25	4.83	6.74	3.70
2319	34.37	2.74	.310	3.87	5.03	8.26	5.66
120	13.25	1.49	16.66	2.14	11.21	26.72	4.42
	1.73	1.19	4.55	3.18	4.96	8.14	2.53
0075	22.93	2.68	.273	3.06	6.09	7.23	5.43
121	12.69	1.55	14.61	2.06	9.90	23.71	4.30
	1.93	1.37	4.13	3.60	4.75	8.00	2.79
0129	24.49	2.92	.283	3.02	5.75	6.56	4.93

APPENDIX TABLE 2. (CONTINUED).

I.D. SOURCE I.S.	PROT. LYS. PXL.	MET. CYS. M+C.	LEU. ISO. I/L.	HIS. ARG. THR.	ALA. TYR. PHE.	GLU. PRO. ASP.	SER. GLY. VAL.
122	12.50	1.39	14.25	2.14	9.32	22.60	4.08
954111	1.76	1.19	3.92	3.33	4.44	7.88	2.66
	21.99	2.57	.275	2.89	5.94	6.27	4.64
123	10.00	1.77	13.64	2.29	9.40	22.28	4.37
954151	2.36	1.58	4.02	4.58	4.61	8.29	3.27
	23.61	3.35	.295	3.16	5.02	6.90	5.02
124	11.06	1.31	14.19	2.10	9.73	22.70	4.25
	1.92	1.27	4.13	4.46	4.78	8.19	2.78
3485	21.19	2.58	.291	2.95	5.11	6.85	4.85
125	9.75	1.67	13.19	2.40	9.38	21.71	4.33
	2.38	1.59	4.02	4.49	4.53	9.50	3.18
0508	23.17	3.26	.305	3.17	4.84	6.79	5.09
126	13.31	1.64	13.93	2.51	9.83	23.41	4.04
	2.18	1.28	4.15	3.60	4.62	8.34	2.77
3935	28.99	2.93	.298	2.95	4.62	6.91	5.08
127	11.12	.55	14.11	2.31	9.36	19.93	4.41
	2.77	.96	4.10	4.62	4.56	8.15	3.65
2319	30.82	1.51	.290	3.58	4.84	8.13	5.49
128	15.56	1.70	14.50	2.16	9.78	23.36	4.01
	1.96	1.37	4.20	4.24	4.80	7.40	2.06
5083	30.49	3.07	.289	2.92	4.99	6.76	5.00
129	12.25	1.32	13.87	2.05	9.37	22.32	4.16
	2.04	1.31	3.92	3.55	4.60	7.62	2.73
2500	25.00	2.63	.283	2.88	4.82	7.17	4.87
130	13.06	1.72	14.69	2.25	9.99	23.51	4.09
954052	1.76	1.64	4.07	3.30	4.86	8.33	2.85
	23.01	3.36	.277	2.86	5.06	6.08	4.97
131	10.25	1.75	13.57	2.29	9.41	22.14	4.08
1X8165	2.08	1.55	3.89	4.28	4.33	7.98	3.03
	21.35	3.30	.286	2.98	4.31	6.55	4.88
132	10.25	1.10	14.70	2.41	10.20	24.12	4.47
2X8165	2.07	1.54	4.16	3.77	4.68	8.48	3.11
	21.25	2.64	.283	3.22	5.08	7.61	5.30

APPENDIX TABLE 2. (CONTINUED).

I.D. SOURCE I.S.	PROT. LYS. PXL.	MET. CYS. M+C.	LEU. ISO. I/L.	HIS. ARG. THR.	ALA. TYR. PHE.	GLU. PRO. ASP.	SER. GLY. VAL.
133	11.94	1.35	14.03	2.26	9.40	22.05	4.14
954239	2.39	1.35	4.17	3.39	4.55	8.56	3.24
	28.53	2.69	.297	3.23	5.50	7.15	5.13
134	10.19	1.93	14.74	2.46	10.36	24.15	4.54
	2.37	1.63	4.26	4.68	5.06	9.87	3.31
8165	24.13	3.56	.289	3.30	5.24	7.18	5.40
136	10.69	1.75	13.72	2.63	9.49	22.27	4.34
	2.25	1.83	4.05	4.21	4.79	9.62	3.19
2939	24.08	3.58	.295	3.24	5.07	6.46	5.06
137	9.69	1.03	14.90	2.64	10.53	22.99	5.03
	2.75	1.44	4.52	4.51	15.04	8.80	3.95
0508	26.62	2.47	.303	3.56	6.04	8.44	5.74
138	11.12	.58	12.90	1.88	9.32	29.02	4.45
	2.62	.65	3.70	4.54	4.11	7.72	3.44
2319	29.16	1.23	.287	3.20	4.79	7.93	5.19
139	13.00	1.74	14.47	2.05	9.93	22.99	4.41
954130	2.08	1.49	4.27	3.89	4.90	9.94	2.95
	27.06	3.23	.295	3.10	5.48	6.65	4.96
140	10.94	1.54	11.87	2.01	8.34	19.30	3.66
	2.13	1.16	3.53	3.79	3.78	6.11	2.74
8165	23.34	2.70	.297	2.72	4.56	6.13	4.46
141	12.25	1.79	14.44	2.08	9.72	23.59	4.22
	1.45	.93	3.88	3.10	4.48	8.13	2.62
0175	17.73	2.72	.269	2.95	5.92	5.98	4.72
142	12.37	1.18	14.68	2.20	9.96	23.66	4.01
954179	1.87	1.13	4.26	3.26	4.76	7.66	2.64
	23.10	2.30	.290	2.79	6.00	6.83	4.89
143	14.00	1.80	14.37	2.30	9.84	23.32	4.25
	2.02	1.65	4.06	3.76	5.53	8.09	3.01
3687	28.30	3.45	.283	3.09	5.53	6.56	5.09
144	10.56	1.93	13.69	2.59	9.51	22.16	4.33
RS690	2.26	1.65	4.03	4.22	4.63	8.17	3.23
	23.89	3.58	.294	3.22	5.72	6.47	5.01

APPENDIX TABLE 2. (CONTINUED).

I.D. SOURCE I.S.	PROT. LYS. PXL.	MET. CYS. M+C.	LEU. ISO. I/L.	HIS. ARG. THR.	ALA. TYR. PHE.	GLU. PRO. ASP.	SER. GLY. VAL.
145	10.87	1.60	13.69	2.27	9.41	21.99	3.91
RS670	1.95	1.32	3.97	3.55	4.31	7.90	2.92
	21.18	2.93	.290	2.96	5.16	6.29	4.98
146	9.13	1.60	13.27	2.69	9.23	21.37	4.50
3R64	2.37	1.61	3.99	4.03	4.49	7.96	3.39
	21.66	3.21	.301	3.31	5.50	6.68	5.02
147	10.63	1.60	13.00	2.32	9.05	21.09	4.08
RS610	2.20	1.48	3.81	3.98	4.53	7.17	3.15
	23.3	3.08	.293	3.07	5.43	6.34	4.87
148	10.56	1.66	13.51	2.25	9.29	21.97	4.26
NK300	2.24	1.42	3.94	4.02	4.60	7.82	3.12
	23.69	3.09	.291	3.08	5.58	6.72	4.92
149	11.12	1.80	13.48	1.97	9.68	21.34	4.27
	2.26	.98	3.94	5.14	4.84	2.69	3.28
2319	25.15	2.77	.292	3.16	4.90	6.98	5.21
150	10.75	1.85	16.00	2.54	11.10	26.58	4.88
640072	2.33	1.69	4.58	4.28	5.20	8.67	3.41
	25.09	3.54	.286	3.51	6.23	7.40	5.57
151	12.25	1.46	13.74	2.42	9.15	21.99	4.27
954021	2.31	1.53	4.23	3.70	4.36	8.16	3.18
	28.26	2.99	.308	3.19	5.58	7.04	5.00
152	8.12	1.31	13.72	2.27	10.46	20.71	4.96
	3.47	.95	4.23	4.68	4.57	4.87	4.46
8260	28.21	2.26	.308	3.81	5.25	9.1	5.79
153	10.25	1.49	15.17	1.93	10.27	24.47	4.55
	1.80	1.30	4.32	3.75	4.87	8.04	2.87
3568	18.41	2.79	.285	3.06	6.09	6.90	4.91
154	12.94	1.51	13.86	2.03	9.53	22.54	4.12
	2.00	1.19	3.96	3.49	4.57	7.59	2.67
0075	25.84	2.70	.286	2.91	5.57	6.67	4.92
155	10.75	1.71	13.96	2.33	9.78	22.98	4.50
	2.37	1.51	4.09	4.16	4.74	7.50	3.30
0104	25.47	3.22	.293	3.30	5.59	6.90	5.19

APPENDIX TABLE 2. (CONTINUED)

I.D.	PROT.	MET.	LEU.	HIS.	ALA.	GLU.	SER.
SOURCE	LYS.	CYS.	ISO.	ARG.	TYR.	PRO.	GLY.
I.S.	PXL.	M+C.	I/L.	THR.	PHE.	ASP.	VAL.
156	11.12	.64	13.26	1.88	9.24	21.24	4.32
	2.52	.95	3.83	4.23	4.34	7.47	3.19
7193	28.01	1.59	.289	3.30	4.81	8.40	5.20
157	10.63	1.60	13.00	2.32	9.05	21.09	4.08
RS610	2.20	1.48	3.81	3.98	4.53	7.17	3.15
	23.39	3.09	.293	3.07	5.43	6.34	4.87
158	12.25	1.67	16.19	2.35	11.08	25.84	4.65
	1.99	1.48	4.41	4.17	5.12	8.31	2.90
3687	24.39	3.16	.272	3.23	6.36	7.06	5.32
159	13.31	1.29	15.55	2.28	10.52	24.98	4.42
	1.79	1.37	4.33	3.35	4.76	8.21	2.76
3979	23.81	2.66	.278	3.07	5.53	6.81	5.02
160	10.63	1.39	16.64	2.40	11.54	25.97	4.47
932070	2.09	.57	4.52	3.79	5.09	9.38	3.25
	22.23	1.96	.271	3.36	5.96	7.75	6.02
161	11.62	1.60	13.48	2.24	9.13	22.09	4.09
222G	1.88	1.48	3.93	3.37	4.16	7.47	2.87
	21.86	3.07	.291	2.96	5.17	5.96	4.67
162	11.62	1.56	13.41	2.19	9.01	21.26	4.05
954066	2.13	1.53	3.91	4.06	4.32	7.99	2.99
	24.71	3.09	.291	3.01	5.21	6.41	4.79
163	10.75	1.71	13.96	2.33	9.78	22.98	4.50
	2.37	1.51	4.09	4.16	4.74	7.50	3.30
0104	25.47	3.22	.293	3.30	5.59	6.90	5.19
164	10.31	1.61	14.36	2.31	9.56	23.02	4.25
	2.01	1.50	4.07	2.53	4.69	7.96	2.86
0345	20.70	3.11	.284	3.42	5.44	6.44	4.96
165	11.62	1.70	13.38	2.25	9.26	22.17	4.08
RS610	2.21	.93	3.99	4.77	4.46	8.57	3.07
	25.67	2.63	.298	3.11	4.99	7.04	5.74
166	13.75	2.20	14.61	2.07	9.80	23.32	4.09
	1.74	1.43	4.32	3.64	4.32	22.60	3.07
3687	23.90	3.64	.295	2.95	4.85	6.52	5.46

APPENDIX TABLE 2, (CONTINUED).

I.D. SOURCE I.S.	PROT. LYS. PXL.	MET. CYS. M+C.	LEU. ISO. I/L.	HIS. ARG. THR.	ALA. TYR. PHE.	GLU. PRO. ASP.	SER. GLY. VAL.
167	12.25	1.67	16.19	2.35	11.08	25.84	4.65
	1.99	1.48	4.41	4.17	5.12	8.31	2.90
3687	24.39	3.16	.272	3.23	6.36	7.06	5.32
168	13.12	1.67	15.28	2.45	10.37	25.17	4.14
3765W	2.01	1.33	4.29	3.84	4.81	8.04	2.94
	26.43	3.00	.281	3.14	5.64	7.11	5.44
169	8.12	1.31	13.72	2.27	10.46	20.71	4.96
	3.47	.95	4.23	4.68	4.57	4.87	4.46
8260	28.21	2.26	.308	3.81	5.25	9.1	5.79
170	11.12	1.89	13.56	2.40	9.70	21.97	4.28
	3.17	1.39	4.11	4.29	4.59	7.09	3.39
2319	35.27	3.28	.303	3.32	5.24	7.39	5.42
171	9.00	1.19	13.81	2.45	10.23	26.35	4.38
BR64	2.30	2.36	3.94	3.88	4.39	7.86	3.50
	20.69	1.17	.285	3.39	4.75	8.42	5.39
172	11.12	.64	13.26	1.88	9.24	21.24	4.32
	2.52	.95	3.83	4.23	4.34	7.47	3.19
7193	28.01	1.59	.289	3.30	4.81	8.40	5.20
173	11.62	1.69	13.36	2.33	9.37	22.44	4.04
RS610	2.17	.95	3.94	4.92	4.42	7.84	3.07
	25.27	2.64	.295	3.09	4.87	6.97	5.48

(1)

I.D. = Sample Number
Source = Purdue Base Number
I.S. = Indian Sorghum Number

Prot. = % Protein
Lys. = % Lysine of Protein
PXL. = Lysine % of Sample x 100

(the following are all given as percent of protein)

Met. = Methionine
Cys. = Cystine
M+C. = Methionine + Cystine

Leu. = Leucine
Iso. = Isoleucine
I/L. = Isoleucine/Leucine Ratio

His. = Histidine
Arg. = Arginine
Thr. = Threonine

Ala. = Alanine
Tyr. = Tyrosine
Phe. = Phenylalanine

Glu. = Glutamic Acid
Pro. = Proline
Asp. = Aspartic Acid

Ser. = Serine
Gly. = Glycine
Val. = Valine