DISTILLERS FEED RESEARCH COUNCIL
Established 1945

CONFERENCE

DISTILLERS FEED CONFERENCE

PROCEEDINGS
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TABLE OF CONTENTS

PRESIDENT'S MESSAGE

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Mr. Otto is Vice President, Feed Recovery Sales for Grain Processing Corp. He has been involved in the feed industry for 20-years primarily in the area of purchasing and sales. Born and raised in western Iowa, he received a B.A. degree from the University of Nebraska-Omaha.

On behalf of the board of directors and members of the Distillers Feed Research Council, may I take this opportunity to welcome you to the 46th Distillers Feed Conference. Your interest and support of this conference is a testament to the value of the Council's continuing commitment to document and share the results of it's research program.

Again, an array of outstanding speakers have been assembled to bring you a variety of information relative to distillers grains research, nutritional concepts and practices and the ever present issue of animal rights. We welcome all of our speakers and hope that they, too, will leave the conference with a more broadened understanding and appreciation of our industry. Also, the conference serves as a platform on which the nutritionist, researcher, agri-business person, ingredient broker and others can share ideas of their respective professions.

In the tradition of the DFRC, it is my privilege to share with you the "state of the Council, so to speak, and to highlight our activities and accomplishments during the past year.

We are extremely proud that South Point Ethanol joined the DFRC family during the past year. A non-profit organization's life's blood is the revenue generated from membership, and associate membership, dues. Of equal importance is the input of new ideas through the expansion of our board of directors, research committee and various sub-committees. Believe me, their contributions thus far are worthy of note and appreciation. We hope that as time goes on, more distillers will follow suit and look to our organization as the key and catalyst for advancing distillers grain (feed) research. Our research efforts underscore the marketing and subsequent utilization of our products.

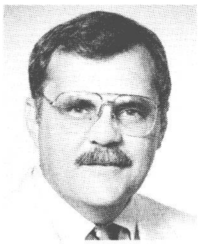
As membership increases, the DFRC Board of Directors, upon the recommendation of the Research Committee, is able to expand the Council's ability to channel more funds toward research. Although we shun "reinventing the wheel" we must continually position ourselves to serve the needs of the animal feeding industry with up-to-date nutritional information regarding distillers grains. No product can claim much in the way of fame unless it contributes in a positive way to the ever important..bottom line.

Of note, is the fact that the Council has expanded it's research program beyond the traditional university environment to include the private research sector. There are definite advantages in this respect, particularly in the speed by which research can be expedited and documented. Also, there is the dimension of conducting research in an industry environment, whereas data generated by any other means are often never fully accepted until it has been put to the acid test of practical, everyday production conditions.

Finally, I want to take this opportunity to commend the efforts put forth by Dr. Hatch in developing a new, modern brochure on distillers grains. Although most of our earlier publications provide a wealth of information on distillers feeds, they are somewhat dated with respect to looks and format and perhaps require more intense study. We trust that you will find this brochure simple in scope, factual and helpful.

Serving as President of the Distillers Feed Research Council provides one with a more thorough and better understanding of the organization, it's history and traditions. Furthermore, it tends to focus attention on the needs of the future. An organization, to better serve its members and clientele, must be consistently moving ahead with new and innovative ideas and programs. It has been a privilege and an honor for me to serve the Council and I will cherish the experience for some time to come.

Again, welcome to our conference. We know you will enjoy the facilities of the Sheraton University Inn, the program, the hospitality suites and particularly the one-on-one contact with your friend and colleagues.



The Distillers Grains Market: A Great Opportunity

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A Minnesota native, Mike concentrated his early career in printing, advertising and marketing and owned his own advertising agency in Grand Forks, North Dakota. Prior to joining the NCGA staff, he was assistant plant manager and marketing director for an ethanol plant in Grafton, North Dakota. Mike joined the staff of the NCGA in 1989 as Market Development Assistant for Ethanol. He is responsible for coordinating and communicating NCGA ethanol programs and activities to expand and enhance the use of corn-dervied ethanol.

The distillation of alcohol for beverage purposes dates back to a time well before the invention of the automobile. Yet, the advancement of the use of alcohols as a fuel extender and toxic emissions reducer has put added pressure on the profitability of the beverage industry.

The fuel alcohol industry is the "new kid on the block" so to speak. While the beverage and the ethanol industry products are targeted for different uses, they have one common problem and that is the marketing of the CO-PRODUCT.

As the ethanol industry begins to fully develop, a glut of distillers grains, corn gluten feed and corn gluten meal is entirely possible. With an uncertain export market, and the potential for decreased use by foreign countries, the problem may be compounded even greater.

How, then, can the Distillers Feed Research Council (DFRC) and the National Corn Growers Association (NCGA) work together to create an even greater demand for alcohol co-products? The NCGA believes strongly that a close working relationship may be beneficial in avoiding a stagnating market with potential reduced profitability.

We know that without the development of new and expanded markets for distillers grains, the profitability of ethanol production will suffer dramatically. Unlike the beverage alcohol industry, the selling price of ethanol is based on the current wholesale price of gasoline. The price of our co-products fluctuates with the price of corn and other competitive feed ingredients.

The fact is, ethanol producers depend on co-product sales for fully one-third of their profitability. Without strong co-product sales, at a profitable price, most ethanol producers would be forced to cease distilling operations.

It is our opinion that the market for distillers grains is a vastly untapped market. The opportunities for expanding this market are almost unlimited. As I'm sure a variety of speakers have or will relate to you at this meeting, continued research into more uses of distillers grains offer potential for increasing the market potential for this product.

What can the NCGA bring to the table to cement a working relationship with the DFRC? Perhaps the two most significant things are ..people and resources. Our organization has nearly 25,000 members in 22 states. Many of these members are ranchers, dairy farmers and poultry producers. We feel that one of our major goals is to educate our members as to the uses of distillers grains. Further, we need to encourage our membership to "TALK IT UP" throughout the countryside on distillers grains. We need to connect all the elements involved to forge a strong market for distillers grains. One of the strongest recommendations farm folks can get is one from a neighbor or friend. There is nothing greater than one producer's success, with a method or product, for spreading the word. With the DFRC,s background in research and data collection, we can begin a grassroots movement that will increase the visibility and value of distillers grains throughout America and the livestock industry.

The NCGA works closely with the United States Feed Grains Council (USFGC). The USFGC is an organization dedicated to the expansion of foreign markets for grain and grain products. We have already had preliminary meetings with them to discuss ways of improving foreign markets for distillers grains. They tell us that the expansion of that market will be one of their priorities in the coming year. We intend to hold their feet to the fire on this issue.

I think that the DRRC has been one of the best kept secrets in history. The outstanding research accomplishments of the Council are legendary. I feel privileged to have been asked to address your conference and to share with you our thoughts and concerns for the future of distillers grains in the market place.

Dr. Hatch and I have, on several occasions, discussed how our respective organizations might complement each other on a common goal. I was also afforded the opportunity to share some of our thoughts with the Council's Board of Directors and Research Committee at their quarterly meeting last Fall. One of the major questions which keeps popping up is, "It's a great idea, but what must we do to get things in motion"? Following, are some suggestions that might get the ball rolling:

1. We need to establish a goal for expanding the current distillers grain market. This goal should be achieved in a realistic time frame. It might be a goal achieved in phases or in one fell swoop, but make no mistake, we need to identify our objectives and develop a plan to meet to meet those objectives.

2. We need to develop a marketing strategy for the industry that helps keep us on course. It would not be out of line for us to pool resources and invite the assistance of a professional marketing firm familiar with feed ingredients and more specifically distillers grains.

3. We should develop informational material targeted at potential customers. In addition to the new DFRC brochure, a video cassette may offer real potential in establishing a basis and method of communicating the nutritional value and feeding recommendations.

4. Prospecting for new uses of distillers grains is vital to developing new markets. Aquaculture, industrial uses and as a human food source are but some of the potentials.

5. Identify research projects that will assist in meeting longterm objectives.

6. The pooling of specific financial resources to carry out research objectives.

The last thing the NCGA is interested in is a duplication of effort. The DFRC's efforts and continuing activities in compiling and making available research information goes back well before the ethanol industry. It is, however, our hope that we can work together in achieving a common objective....the marketing of increasing volumes of distillers grains on a profitable basis.

I must tell you that as an organization dedicated to the increasing use of corn worldwide, we must address utilization of other co-products such as corn gluten feed. However, we recognize that many of the smaller distilleries which market distillers grains do not have the resources to tackle such a major project. The market expansion of one co-product while ignoring another made from corn does not solve the problem. If we solely concentrate on distillers grains and let corn gluten feed, for example, fend for itself, we will simply have created a low priced competitor for distillers grains. We must address the co-product market as a whole market. Anything less would simply come back to haunt us in the future.

The issue of co-product market expansion is a tremendous opportunity for increased profits. It's really something that should have been addressed years ago. As a representative of the NCGA, I would like to extend our hand in hopes that, together, we can explore new frontiers of growth and profit for distillers grains.

Physical, Chemical and Nutritional Characteristics of Nine Samples of Distillers Dried Grains with Solubles for Chicks and Pigs

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Born and reared on a Kansas wheat and livestock farm, **Dr. Cromwell** received his B.S. degree in Agricultural Education from Kansas State University. After teaching vocational agriculture for four years, he earned an M.S. and Ph.D. degree in animal nutrition from Purdue University. He joined the staff at the University of Kentucky in 1967 where he has been continually involved in teaching and research of swine management and nutrition. Dr. Cromwell has authored many scientific papers and abstracts. He served as President of the American Society of Animal Science for 1989-90. Dr. Cromwell was recipient of the D.F.R.C.'s Distinguished Nutritionist Award in 1986.

SUMMARY

The physical characteristics, chemical composition and nutritional value of distillers dried grains with solubles (DDGS) from seven beverage alcohol and two fuel alcohol manufacturers were evaluated in studies with chicks and pigs. Color scores of the DDGS ranged from very light to very dark and odor scores ranged from normal to burnt or smoky. The DDGS ranged from 23.4 to 28.7% protein, 2.9 to 12.8% fat, 28.8 to 40.3% NDF, 10.3 to 18.1% ADF and 3.4 to 7.3% ash. Lysine concentrations of the DDGS ranged from .43 to .89%. In the first experiment, 12 corn-based diets were fed to 1-day-old chicks for 21 days to assess the nutritional value of the DDGS sources. A low-protein (13.6%) basal diet was supplemented with soybean meal to provide 13.6, 16.5 or 19.0% protein or supplemented with 20% DDGS, which supplied approximately the same amount of protein as the highest level of soybean meal. Weight gain, feed intake and feed/gain were influenced ($P<.01$) by source of DDGS. Weight gain was regressed on protein intake for chicks fed the basal and the soybean meal diets, and for chicks fed the basal and each source of DDGS. Slope-ratio analysis indicated that the nutritional value of the DDGS sources ranged from 0 to 61 as compared with a value arbitrarily set at 100 for soybean meal. Blends of DDGS were evaluated in a subsequent chick trial and the results confirmed the results of the first experiment. Responses to various blends of DDGS in the pig experiment paralleled those of the chick trial. The relative nutritional indices of three blends of DDGS for pigs were 49, 17 and 0. Rate and efficiency of gain were correlated with color and concentrations of protein, lysine and ADF in the DDGS. The results indicate that large variabilities in physical, chemical and nutritional properties exist among the sources of DDGS that are available to the feed industry.

Key Words: Distillers dried grains, pigs, chicks.

Introduction

Distillers dried grains with solubles (DDGS) is a by-product resulting from the fermentation of cereal grains for the production of alcohol for beverage or fuel. DDGS has long been recognized as a valuable source of energy, protein, water-soluble vitamins and minerals for animals. Some of the early research studies with pigs indicated that distillers dried solubles provided a source of unidentified growth factors (Catron et al., 1954, 1955; Gage et al., 1961), but more recent studies have not shown an unidentified growth factor effect from the inclusion of distillers dried solubles in practical swine diets (Conrad, 1961; NCR-42 Committee on Swine Nutrition, 1970).

Dietary inclusion of DDGS is normally limited to 5 to 10% in swine and poultry diets. Studies at the University of Kentucky and reported at this conference in 1986 showed that up to 20% DDGS can be included, on a lysine basis, in diets for growing-finishing swine with only a slight (3-4%) reduction in growth rate and efficiency of feed utilization (Cromwell and Stahly, 1986).

Various methods are used in the preparation of DDGS. Often, the end product will vary in physical appearance and in chemical composition, depending on the grains used and the processing and drying procedures. Overheating oilseed meals and animal protein meals causes reduced availability of lysine and destruction of other amino acids (Carpenter, 1960; Rios-Iriarte and Barnes, 1966; McNaughton and Reece, 1980), and perhaps this also occurs with DDGS. Whether processing and drying conditions have a minor or major effect on the nutritional value of DDGS is not well understood.

The objectives of this study were to assess the degree of variability in the physical properties and chemical composition of various sources of DDGS from beverage and fuel alcohol production, to assess the variability in the nutritional value of different sources of DDGS for chicks and pigs, and to establish relationships between the physical properties, chemical composition and nutritional value of DDGS for nonruminants.

PROCEDURES

Nine sources of DDGS were obtained for this study (Table 1). Seven sources were DDGS that originated from the production of beverage alcohol and two sources were from plants that produced fuel alcohol from corn. The beverage alcohol-derived DDGS sources were provided by the Distillers Feed Research Council, and the specific companies were not known by the investigators. These sources were identified as Sources A through G. The other two sources were obtained from fuel-alcohol plants in Kentucky (Southpoint Ethanol, Ashland Oil Co., Ashland, KY; Kentucky Agricultural Energy Corporation, Franklin, KY). They were identified as Sources H and I (but not necessarily in this respective order).

Physical characteristics (odor and color) of the nine sources of DDGS were assessed by a three-member panel. Color was subjectively scored from 1 to 5, with 1 representing a very light color and 5 representing a very dark color. The nine sources also were ranked by the panel from the lightest to the darkest. In addition, the Hunterlab color procedure (McNaughton et al., 1981) was used to quantitatively assess the lightness, redness and yellowness of the nine samples.

The nine sources were analyzed for dry matter, crude protein, ether extract and ash in our laboratory, using standard procedures (AOAC, 1984; Table 2). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined by the method of Goering and Van Soest (1970). The samples also were analyzed for amino acids by ion-exchange chromatography (Courtesy of Heartland Lysine, Inc., Chicago, IL; Table 3).

Chick Experiments. Two experiments were conducted with chicks to assess the nutritional value of the nine sources of DDGS. In both experiments, 1-day-old broiler-type chicks (males of a female parent line, Hubbard Farms, Statesville, NC) were used. The chicks were housed in batteries (Petersime Incubator Co., Gettysburgh, OH) and were allowed to consume their diets and water on an ad libitum basis.

The composition of the diets in Exp. 1 is shown in Table 4. Diet 1 was a 13.6% protein, corn-soybean meal diet containing 20% of a starch-cellulose mixture. The starch-cellulose mixture was calculated to be isocaloric with DDGS (2,480 kcal ME/kg; NRC, 1984). Diets 2 and 3 contained 16.5 and 19.0% protein, respectively, with additional soybean meal replacing a portion of the starch-cellulose mixture. The higher protein diet was calculated to be slightly deficient in crude protein as compared with levels listed by NRC (1984). Diets 4 to 12 consisted of the basal diet with one of the nine sources of DDGS replacing the starch-cellulose mixture. These nine diets contained approximately 19% protein. The rational behind formulating the diets this way was so that each source of DDGS could be directly compared, on a protein basis, with an equivalent amount of soybean meal protein. The amount of corn was held constant in each diet so that it would not be a contributing factor. Each treatment was replicated four times, with eight chicks per pen. The experiment was conducted for 21 days.

In Exp. 2, two blends of DDGS were evaluated. One blend was a combination of Sources B, C and D and the second blend was a combination of Sources A, E and H. Each blend consisted of equal parts, by weight, of the three sources of DDGS. Diet 1 (Table 5) was a 12% protein, corn-soybean meal diet with 30% corn starch. Diets 2, 3 and 4 consisted of the basal diet with soybean meal substituted for starch to provide 14.7, 17.4 and 20.1% protein, respectively. Diets 5, 6 and 7 consisted of the basal diet with 10, 20 or 30% DDGS (blend of Sources B, C and D) replacing corn starch. These three diets also contained approximately the same levels of protein as Diets 2, 3 and 4, respectively. Diets 8, 9 and 10 were the same as Diets 5, 6 and 7 except that the DDGS blend consisted of Sources A, E and H. There were four pen-replicates for each treatment except for treatment 1 (the basal diet), in which case there were 12 replications. There were eight chicks in each pen. The experimental period was 14 days.

Pig Experiment. This experiment was conducted to evaluate three blends of DDGS for growing pigs. Hampshire-Yorkshire pigs initially averaging 16.0 kg were used in the study. The pigs were randomly allotted to treatments from outcome groups based on weight and sex, with six pen-replicates per treatment and one pig per pen. The pigs were housed in elevated pens (.6 x 1.2 m) with expanded metal floors in a temperature-regulated building. The pigs were allowed to consume their feed and water ad libitum.

Six dietary treatments were evaluated (Table 6). Diet 1 was a corn-soybean meal diet containing 23.4% of a dextrose-corn starch mixture. This diet was calculated to contain 8.6% protein. The soybean meal was increased in Diets 2 and 3 (substituted for dextrose-starch) to provide 11.3 and 14% dietary protein. The 14% protein diet was calculated to be slightly deficient in lysine for pigs of this weight classification (NRC, 1988). Diets 4, 5 and 6 consisted of the basal diet with 20% DDGS substituted for the dextrose-starch mixture. The blends (1:1 by weight) of DDGS were Sources B and D (Diet 4), G and I (Diet 5) and A and E (Diet 6). These three diets contained approximately the same level of protein (~14%) as the diet with the highest level of soybean meal (Diet 3). The level of corn was held constant in all diets.

Statistical Analysis. The data of each experiment were analyzed by variance procedures (Steel and Torrie, 1980) using the GLM procedure of SAS (1985). Levels of soybean meal in all three experiments and levels of the DDGS blend in Exp. 2 were tested for linearity and nonlinearity. Individual sources or blends of DDGS were compared using a protected F-test and the least significant difference (LSD) test. Performance traits were regressed on protein intake and slope ratio analyses were used to compare each DDGS source or blend with soybean meal. A relative value, or index, was then calculated for each DDGS source, with the value being relative to that for soybean meal, which was arbitrarily given an index value of 100. Correlations were tested between various physical and chemical characteristics of the DDGS and performance traits. In each experiment, the pen was considered the experimental unit.

Results and Discussion

Physical Properties. Table 1 shows the physical characteristics of the nine sources of DDGS. Sources A and F had a slightly burnt odor and Source H had a definite burnt odor. Source E had a definite smoky odor. All of the other sources had an odor that was typical of a dried fermented product such as DDGS.

Subjective color scores by the panel ranged from 1 (very light) to 5 (very dark). The four samples that had a burnt or smoky odor were darker in color, with subjective scores of 4 or 5.

The Hunterlab color procedure gives a score to a sample based on its lightness or darkness, redness and yellowness. The Hunterlab L score ranges from 0 (black) to 100 (white). Positive Hunterlab a and b scores indicate redness and yellowness, respectively, with higher scores indicating a greater degree of each color. The Hunterlab L scores (Table 1) ranged from 53.2 (lightest, Source B) to 28.9 (darkest, Source F). The ranking of the DDGS sources by the Hunterlab L method essentially duplicated the ranking of the sources by the panel. According to the Hunterlab L scores, the nine sources fell into three main categories, B and D (lightest), C, G and I (medium) and A, E, F and H (darkest). Again, this agreed very closely with the subjective scores of the panel. The Hunterlab b (yellowness) scores ranked the nine sources in the same order as the L scores, but the Hunterlab a (redness) scores did not.

Chemical Characteristics. The chemical composition of the nine sources of DDGS is shown in Table 2. The dry matter of the nine samples averaged 90.5% with a range of 87.1 to 91.9%. Crude protein ranged from 23.4 to 28.7%, with an overall average of 26.9%, which agrees with the value of 27.0% protein listed by NRC (1988). Source E was considerably lower in protein (23.4%) than any of the others. Ether extract averaged 9.7%, which agrees closely with the value of 9.3% listed by NRC (1988), but the fat content among the sources was quite variable. Most of the samples ranged from 9 to 12% fat, but one sample (Source C) contained only 2.9% fat. The fiber and ash contents of the nine sources also varied considerably. Lightness or darkness did not appear to be related to any of these chemical measurements except for ADF, in which case increasing darkness was associated with increased ADF content (r=.62).

The lysine, tryptophan, threonine and sulfur-amino acid concentrations of the DDGS sources are shown in Table 3. Lysine is the most critical amino acid because it is the first limiting amino acid for pigs and second limiting for chicks. Lysine was extremely variable, ranging from .43 to .89%. The other amino acids did not appear to be as variable as lysine. The average lysine content in DDGS (.71%) was about the same as the .70% lysine cited by NRC (1988), but the average concentrations of tryptophan (.20%), threonine (1.02%) and methionine + cystine (1.04%) were greater than the .17, .92 and .78%, respectively, listed by NRC (1988).

On average, lysine tended to be highest in the lightest-colored DDGS (.86%, B and D), intermediate in the medium (.74%, C, G and I) and lowest in the darkest- colored DDGS (.62%, A, E, F and H). The four darker sources of DDGS were lower in the sulfur-amino acids as compared with the other five sources (.99 vs 1.09%). There was no pattern between color and percentages of threonine or tryptophan in DDGS.

Lysine content of DDGS decreased as protein content decreased. The correlation between protein and lysine was high (r=.80; P>.01), but this is partially due to Source E being considerably lower in protein and lysine than the other eight sources of DDGS. When Source E is excluded, the correlation between protein and lysine among the remaining eight sources of DDGS was considerably less (r=.43) and not significant (P>.20). The low correlation between protein and lysine is characteristic of corn (Reese and Lewis, 1989; unpublished data, NRC-42 Committee on Swine Nutrition) as well as other cereal grains.

Chick Experiment 1. The results of the first chick experiment are shown in Table 7. Weight gain and feed intake increased linearly (P<.01) and feed/gain decreased linearly (P<.01) as the level of soybean meal increased in the diet. Growth rate differed (P<.01) among chicks fed the various sources of DDGS, ranging from 364 g/day for chicks fed Source E to 488 and 489 g/day for those fed Sources B and C, respectively. Source E (which had a smoky odor and possessed the lowest lysine content) was consumed in the least amount and resulted in the poorest gain and feed/gain of the nine sources tested. On average, chicks fed diets containing DDGS gained slower (434 g/day) and required more feed per unit of gain (1.64) than those fed diets in which an equivalent amount of protein was supplied by soybean meal (577 g/day; 1.49 feed/gain).

An index was determined for each source of DDGS by a single-point slope-ratio assay. An example of this procedure is shown in Figure 1. In this procedure, the slope of a regression line for the a test ingredient (in this case, DDGS) is divided by the slope of the regression line for the standard (i.e., soybean meal) and the result is multiplied by 100. The basal diet is used to calculate both regressions. The nutritional value (calculated index) of the DDGS is relative to the nutritional value of soybean meal, which is arbitrarily given a value of 100. The regressions must be linear for the test to be valid. The single-point regression also assumes that if lesser amounts of the test source are consumed, the response would fall on the regression line (which was confirmed in Exp. 2).

Figure 2 shows the weight gain of the chicks regressed on protein intake. Regressing on protein intake corrects for differences in feed intake (thus, differences in protein intake), and results in a linear regression of the basal diet and the two levels of soybean meal on protein intake. The r^2 value of .995 indicates an excellent fit of the data to the linear regression line for soybean meal. The relative value (Figure 2) of the various sources of DDGS ranged from less than 0 (Source E) and 11 (Source A) to 60, 59 and 61 for Sources B, C and D. The relative values of the other four DDGS sources ranged from 29 to 48.

Chick Experiment 2. The purpose of this experiment was to evaluate two blends of DDGS and to determine if graded levels of the blends resulted in linear responses in weight gain when regressed on protein intake. As discussed previously, a linear response is necessary for the relative response values to be valid. Selection of the DDGS sources for the two blends was based on the relative values for each source obtained in Exp. 1. Sources B, C and D (Blend 1) had the three highest indices in Exp. 1 and Sources A, E and H (Blend 2) had the three lowest indices.

The results are shown in Table 8. Rate and efficiency of gain improved linearly (P<.01) with increasing levels of soybean meal in the diet. Improvements in performance also occurred (P<.01) with increasing levels of DDGS, but the improvements were less than for soybean meal additions. Regression of weight gain on protein intake (Figure 3) resulted in excellent fits of the data to the regression lines, with r^2 values of .989, .990 and .958. These results confirm the validity of the single point estimates of Exp. 1 and further indicate that the nutritional value of DDGS Sources B, C and D was clearly superior to that of Sources A, E and H. The relative nutritional value was 48 for the B,C,D blend and 14 for the A,E,H blend of DDGS.

Pig Experiment. The purpose of this experiment was to determine if the relative indices of nutritional value for the DDGS sources obtained in the chick experiment would also apply to pigs. The three blends of DDGS tested in this experiment represented two each of the best (B and D), average (G and I) and poorest (A and E) sources of DDGS, based on the results of the chick tests.

The results are shown in Table 9. Growth rate and feed/gain improved linearly ($P<.01$) with increasing level of soybean meal in the diet. There were differences ($P<.05$) among the three blends with the order being the same as one would predict from the chick data. Based on slope-ratios (Figure 4), the blend of Sources B and D had a value that was 49% of soybean meal. The blend of Sources G and I had a value of 17 and the blend of sources A and E had an index of less than 0.

Correlation of Physical and Chemical Properties With Performance. Table 10 shows the correlations of color and chemical properties of DDGS with weight gain and feed/gain of chicks and index score of the nine sources of DDGS. These data are based on the results of the first chick experiment because blends of DDGS sources were used in the other experiments.

Subjective color score and Hunterlab L (lightness/darkness) and b (yellowness) scores were highly correlated with chick performance, while Hunterlab a (redness) scores were poorly correlated. Crude protein, lysine and sulfur-amino acid contents of the DDGS were highly correlated with feed conversion efficiency and moderately correlated with growth rate and relative index score. ADF content of the DDGS was more highly correlated to performance than NDF content. Percentage ash and fat in the DDGS did not appear to be closely associated with chick performance. The relationships of Hunterlab L score and lysine content of DDGS with weight gain and feed/gain of chicks are shown in Figures 5 to 8.

Implications. The results of this research indicate that large variabilities in physical, chemical and nutritional properties exist among the sources of DDGS that are available to the feed industry. Based on our studies, odor and color are valuable criteria in determining the nutritional value of DDGS for nonruminants. DDGS with a light color and those that are free from burnt or smoky odor are more likely to have good nutritional properties. DDGS with high lysine and low ADF is preferable. Although protein and lysine in DDGS were correlated, a high or low crude protein content in DDGS does not necessarily mean that the lysine level will also be high or low, respectively. The nutritional value of the by-product of fuel alcohol production appears to be similar to that of DDGS from beverage alcohol production.

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TABLE 1. PHYSICAL CHARACTERISTICS OF NINE SOURCES OF DISTILLERS DRIED GRAINS WITH SOLUBLES.

Source[a]	Odor	Color score[b]	Color rank[c]	Hunterlab[d] L	a	b
A	Slightly burnt	4	7	29.0	6.5	12.7
B		1	1	53.2	4.7	21.8
C		3	4	40.1	7.1	17.3
D		2	2	51.7	7.1	24.1
E	Smoky	4	8	31.1	6.1	13.1
F	Slightly burnt	5	9	28.9	6.2	12.4
G		3	5	38.8	6.8	16.5
H	Burnt	4	6	32.1	6.6	13.0
I		3	3	41.8	6.5	18.8
Avg		3		38.5	6.4	16.6
High		5		53.2	7.1	24.1
Low		1		28.9	4.7	12.4

[a]Samples A - G are from beverage alcohol production. Samples H and I are from fuel alcohol production.
[b]1=very light, 2=light, 3=medium, 4=dark, 5=very dark.
[c]Rankings = 1 to 9, lightest to darkest.
[d]L=Lightness of sample, 0=black, 100=white; The higher the value of a and b the greater degree of redness and yellowness, respectively.

TABLE 2. CHEMICAL CHARACTERISTICS OF NINE SOURCES OF DISTILLERS DRIED GRAINS WITH SOLUBLES.

Source[a]	Dry matter, %	Crude protein, %	Ether extract, %	NDF, %	ADF, %	Ash, %
A	92.7	27.9	9.5	35.4	15.5	5.2
B	91.8	26.7	9.0	36.1	12.9	3.4
C	90.6	27.0	2.9	33.3	10.3	7.3
D	90.5	28.7	11.8	30.7	10.3	3.7
E	89.9	23.4	9.5	38.5	13.7	6.1
F	90.5	26.7	12.3	34.8	16.6	4.2
G	91.9	27.4	8.1	40.3	15.3	3.4
H	87.1	26.8	12.8	28.8	18.1	5.3
I	89.6	27.4	11.5	38.5	16.4	4.8
Avg	90.5	26.9	9.7	35.1	14.4	4.8
High	91.9	28.7	12.8	40.3	18.1	7.3
Low	87.1	23.4	2.9	28.8	10.3	3.4

[a]Samples A - G are from beverage alcohol production. Samples H and I are from fuel alcohol production.

TABLE 3. AMINO ACID COMPOSITION OF NINE SOURCES OF DISTILLERS DRIED GRAINS WITH SOLUBLES.

	Amino acid, %			
Source[a]	Lysine	Tryptophan	Threonine	Methionine + cystine
A	.79	.23	1.12	1.03
B	.89	.18	.91	1.14
C	.68	.22	.98	1.05
D	.82	.22	1.16	1.02
E	.43	.19	.90	.88
F	.65	.16	1.04	1.04
G	.77	.20	1.09	1.13
H	.59	.18	1.08	1.00
I	.76	.21	.89	1.11
Avg	.71	.20	1.02	1.04
High	.89	.23	1.16	1.14
Low	.43	.16	.89	.88

[a]Samples A - G are from beverage alcohol production. Samples H and I are from fuel alcohol production.

TABLE 4. COMPOSITION OF DIETS, % - EXPERIMENT 1.[a]

Ingredient	Diet 1	Diet 2	Diet 3	Diets 4-12
Corn	46.28	46.28	46.28	46.28
Soybean meal, 44% CP	21.92	28.57	34.24	21.92
Corn starch-cellulose	20.00	13.35	7.68	
DDGS (Sources A - I)				20.00
Corn oil	7.10	7.10	7.10	7.10
Dicalcium phosphate	1.85	1.85	1.85	1.85
Limestone	1.35	1.35	1.35	1.35
Salt	.50	.50	.50	.50
Vitamins-minerals[b]	1.00	1.00	1.00	1.00
Calculated analysis				
Crude protein	13.6	16.5	19.0	~19.0
ME (kcal/kg)	3,160	3,160	3,160	~3,160

[a]Each diet fed to four pen-replicates of eight 1-day-old chicks/pen for 21 days.
[b]Added at levels to meet or exceed NRC (1984) standards.

TABLE 5. COMPOSITION OF DIETS, % - EXPERIMENT 2.[a]

Ingredient	Diet									
	1	2	3	4	5	6	7	8	9	10
Corn	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Soybean meal, 44% CP	19.0	25.1	31.3	37.4	19.0	19.0	19.0	19.0	19.0	19.0
Corn starch	30.0	22.2	14.3	6.5	20.0	10.0		20.0	10.0	
DDGS (Sources B,C,D)					10.0	20.0	30.0			
DDGS (Sources A,E,H)								10.0	20.0	30.0
Corn oil	3.0	4.7	6.4	8.1	3.0	3.0	3.0	3.0	3.0	3.0
Dicalcium phosphate	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Limestone	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Salt	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5
Vitamins-minerals[b]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
DL-methionine	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
Calculated analysis										
Crude protein	12.0	14.7	17.4	20.1	14.7	17.5	20.2	14.6	17.2	19.8
ME (kcal/kg)	3,225	3,225	3,225	3,225	3,109	2,990	2,873	3,109	2,990	2,873

[a]Each diet fed to four pen-replicates of eight one-day-old chicks/pen for 14 days.
[b]Added at levels to meet or exceed NRC (1984) standards.

TABLE 6. COMPOSITION OF DIETS, % - EXPERIMENT 3.[a]

Ingredient	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6
Corn	68.22	68.22	68.22	68.22	68.22	68.22
Soybean meal, 48.5% CP	5.79	11.37	16.93	5.79	5.79	5.79
Corn starch	11.68	8.89	6.11	1.68	1.68	1.68
Dextrose	11.68	8.89	6.11	1.68	1.68	1.68
DDGS (Sources B,D)				20.00		
DDGS (Sources G,I)					20.00	
DDGS (Sources A,E)						20.00
Dicalcium phosphate	1.47	1.47	1.47	1.47	1.47	1.47
Limestone	.56	.56	.56	.56	.56	.56
Salt	.40	.40	.40	.40	.40	.40
Vitamins-minerals[b]	.15	.15	.15	.15	.15	.15
Antibiotic[c]	.05	.05	.05	.05	.05	.05
Calculated analysis						
Crude protein	8.6	11.3	14.0	13.7	14.1	14.1
ME (kcal/kg)	3,379	3,363	3,348	3,313	3,313	3,313

[a]Each diet fed to six individually-penned pigs initially weighing 16.0 kg for 28 days.
[b]Added at levels to meet or exceed NRC (1988) standards.
[c]Provided 55 mg chlortetracycline per kg.

TABLE 7. PERFORMANCE OF CHICKS FED NINE SOURCES OF DDGS - EXPERIMENT 1.[a]

Diet	Crude protein, %	Chick weight gain, g[bc]	Chick feed intake, g[bc]	Feed/gain[bc]
Basal	13.5	373	680	1.82
+ Soybean meal	16.3	513	826	1.61
+ Soybean meal	19.0	577	860	1.49
+ Source A	~19.0	390	640	1.64
+ Source B	~19.0	489	778	1.59
+ Source C	~19.0	488	796	1.63
+ Source D	~19.0	477	760	1.59
+ Source E	~19.0	364	631	1.73
+ Source F	~19.0	447	731	1.64
+ Source G	~19.0	422	700	1.66
+ Source H	~19.0	407	701	1.72
+ Source I	~19.0	425	671	1.58
LSD ($P < .05$)		54	80	.06

[a]Each mean represents four pen-replicates of eight chicks/pen; 21-day test.
[b]Linear response to level of soybean meal ($P<.01$).
[c]Difference among DDGS sources ($P<.01$).

TABLE 8. PERFORMANCE OF CHICKS FED TWO BLENDS (THREE SOURCES/ BLEND) OF DDGS - EXPERIMENT 2.[a]

Diet	Crude protein, %	Chick weight gain, g[bcde]	Chick feed intake, g[bde]	Feed/gain[bcde]
Corn-soybean meal	12.0	175	316	1.81
	14.7	261	399	1.53
	17.4	309	408	1.33
	20.1	330	402	1.22
DDGS Sources B,C,D	14.6	200	336	1.68
	17.2	213	344	1.61
	19.8	244	380	1.56
DDGS Sources A,E,H	14.7	180	313	1.74
	17.5	174	297	1.72
	20.2	188	315	1.68
LSD ($P < .05$)		20	29	.04

[a]Each mean represents four pen-replicates of eight chicks/pen; 14-day test.
[b]Linear response to level of soybean meal ($P<.01$).
[c]Quadratic response to level of DDGS B,C,D ($P<.01$).
[d]Linear and quadratic response to level of DDGS A,E,H ($P<.01$).
[e]Difference between DDGS blends ($P<.01$).