## *Soybean Checkoff-funded Research*

**Project Title:** Global Soybean Meal Sampling and Analysis Activity

**Investigator:** John C. Baize, John C. Baize and Associates, 7124 Carol Lane, Falls Church, VA 22042-3714.

**Reference:** USB Project #0586 (August 2, 2000). American Soybean Association, 12125 Woodcrest Executive Drive, Suite 100, St. Louis, Mo 63141 and United Soybean Board, 16305 Swingley Ridge Road, Suite 150, Chesterfield, MO 63017.

**Overall Objective:**
In October, 1999 John C. Baize and Associates contracted with Smith Bucklin& Associates (SBA) to undertake to carry out a global soybean meal sampling and analysis project (USB Project # 0586) on behalf of the Quality Committee of the United Soybean Board. With the decision by the USB to eliminate the Quality Committee in December 1999 management of the project was subsequently transferred to the American Soybean Association (ASA), the USB's international marketing contractor.

Sample Collection. The project was begun in October 1999 with requests being sent to ASA's foreign office directors in Beijing, Tokyo, Seoul, Singapore, Brussels, Vienna, and Istanbul. These offices were selected because they are responsible for countries where US soybean meal is imported and must compete with soybean meal exported by Argentina, India, Brazil, and the European Union.

A total of 71 soybean meal samples were received by John C. Baize and Associates from ASA's foreign office staff. The offices that collected and sent samples were as follows:

| | | | |
|---|---|---|---|
| Istanbul | 15 samples | Beijing | 2 samples |
| Seoul | 3 samples | Vienna | 18 samples |
| Singapore | 33 samples | | |

Of the 71 soybean meal samples sent to John C. Baize and Associates the following meal origins were received:

| | | | |
|---|---|---|---|
| USA | 17 samples | India | 17 samples |
| Argentina | 10 samples | China | 1 sample |
| Brazil | 14 samples | EU | 8 samples |
| Syria | 1 sample | Malaysia | 1 sample |
| Philippines | 2 samples | | |

It is important to note that it was not possible to collect samples of soybean meal using methodologies that assured the samples were representative of the overall meal shipments. Instead, samplers attempted to collect samples that appeared as much as possible to represent the overall shipments. It is assumed that was done.

Analysis Methodology. All samples collected by ASA foreign staff were sent to John C. Baize where they were assigned a number provided by the Grain Quality Laboratory at Iowa State

University. At this time the samples' origin and country of collection were entered into a database. All samples were then sent by UPS to the Grain Quality Laboratory at Iowa State University.

When the staff at the Iowa State Grain Quality Laboratory received the samples, all were thoroughly mixed and ground and then split into 4 sub-samples. In the case of a few samples the volume was insufficient to create 4 sub-samples and only 2 were created. Two of the sub-samples were sent at different times to Woodson-Tenent Laboratories in Des Moines, Iowa where all were analyzed for moisture, crude protein, crude fiber, and fat/oil content. One of the sub-samples was analyzed for protein solubility (KOH method). The Iowa State Grain Quality Laboratory sent the remaining two sub-samples to the University of Missouri where each was analyzed for amino acids. This procedure resulted in all but a few samples being analyzed in duplicate for crude protein, crude fiber, fat/oil, and amino acids and once for protein solubility.

Once the results of laboratory analyses by Woodson-Tenent and the University of Missouri were received by the ISU Grain Quality Laboratory, all analysis results data were corrected mathematically to a 12% moisture basis to allow a fair comparison of the various samples for the various factors analyzed. The data were then sent to John C. Baize and Associates for compilation and statistical analysis.

Results of Sample Analysis. The following are the average moisture, protein, fiber, fat, amino acid, and KOH protein solubility levels of the soybean meals analyzed:

**Table I.** Summary of Soymeal Analysis Data

| **Characteristic** | **US Hi-Pro** | **US Low-Pro** | **Argentine Hi-Pro** | **Argentine Low-Pro** | **Brazilian Hi-Pro** | **Brazilian Low-Pro** | **Indian Meal** | **EU Meal** |
|---|---|---|---|---|---|---|---|---|
| # Samples | 14 | 2 | 2 | 8 | 5 | 9 | 17 | 8 |
| Moisture | 11.04 | 11.71 | 11.82 | 11.63 | 11.87 | 9.80 | 11.61 | 10.89 |
| Protein | 48.61 | 45.44 | 46.83 | 44.81 | 48.91 | 46.94 | 46.98 | 47.79 |
| Fat | 1.45 | 1.77 | 2.26 | 1.72 | 1.65 | 1.56 | 1.03 | 1.40 |
| Fiber | 3.66 | 5.38 | 3.49 | 5.86 | 3.75 | 5.90 | 6.09 | 3.89 |
| KOH Solubility | 84.08 | 85.50 | 74.87 | 76.82 | 78.98 | 80.64 | 80.96 | 82.32 |
| Lysine | 3.04 | 2.91 | 2.86 | 2.85 | 2.95 | 2.82 | 2.92 | 2.88 |
| Methionine | 0.69 | 0.65 | 0.64 | 0.61 | 0.67 | 0.61 | 0.64 | 0.67 |
| Threonine | 1.85 | 1.75 | 1.81 | 1.73 | 1.86 | 1.76 | 1.81 | 1.81 |
| Cystine | 0.75 | 0.72 | 0.72 | 0.66 | 0.76 | 0.68 | 0.68 | 0.75 |
| Tryptophane | 0.70 | 0.66 | 0.64 | 0.63 | 0.70 | 0.67 | 0.66 | 0.69 |
| Taurine | 0.05 | 0.07 | 0.06 | 0.05 | 0.04 | 0.04 | 0.05 | 0.03 |
| Hydroproline | 0.05 | 0.05 | 0.07 | 0.08 | 0.07 | 0.10 | 0.09 | 0.06 |
| Aspartic Acid | 5.36 | 5.07 | 5.19 | 4.97 | 5.48 | 5.15 | 5.33 | 5.26 |
| Serine | 2.14 | 1.96 | 2.25 | 2.04 | 2.33 | 2.12 | 2.24 | 2.13 |
| Glutamine | 8.70 | 8.19 | 8.53 | 8.01 | 9.02 | 8.43 | 8.72 | 8.72 |
| Proline | 2.32 | 2.18 | 2.29 | 2.12 | 2.43 | 2.27 | 2.29 | 2.36 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Lanthionine | 0.01 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Glycine | 1.98 | 1.92 | 1.91 | 1.88 | 1.98 | 1.89 | 1.95 | 1.92 |
| Alanine | 2.07 | 1.99 | 2.01 | 1.93 | 2.08 | 1.97 | 2.03 | 2.02 |
| Valine | 2.29 | 2.21 | 2.25 | 2.19 | 2.23 | 2.16 | 2.24 | 2.21 |
| Isoleucine | 2.12 | 2.02 | 2.05 | 1.98 | 2.09 | 2.02 | 2.09 | 2.04 |
| Leucine | 3.70 | 3.51 | 3.62 | 3.47 | 3.74 | 3.56 | 3.66 | 3.60 |
| Tyrosine | 1.71 | 1.63 | 1.62 | 1.61 | 1.70 | 1.65 | 1.68 | 1.68 |
| Phenylalanine | 2.45 | 2.33 | 2.37 | 2.30 | 2.49 | 2.37 | 2.41 | 2.39 |
| Hydroxylysine | 0.02 | 0.02 | 0.00 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 |
| Histidine | 1.29 | 1.23 | 1.23 | 1.22 | 1.27 | 1.22 | 1.25 | 1.25 |
| Ornithine | 0.03 | 0.04 | 0.04 | 0.05 | 0.04 | 0.03 | 0.04 | 0.03 |
| Arginine | 3.51 | 3.33 | 3.43 | 3.29 | 3.58 | 3.40 | 3.41 | 3.46 |
| Total Amino Acids | 46.83 | 44.47 | 45.59 | 43.69 | 47.49 | 44.93 | 46.20 | 45.76 |

The only factor utilized to classify a soybean meal as low-pro (non-dehulled) or high-pro (dehulled) was the crude fiber content of the meal. If the average crude fiber content of a sample was 4% or lower it was classified as high-pro meal while samples over 4% were classified as low-pro meal. This is an arbitrary dividing line. However, it is generally recognized that any dehulled soybean meal should have a fiber content of less than 4%.

Analysis of Results. The data above shows the US soybean meal generally is of superior quality to soybean meals from other origins in terms of its projected digestibility (KOH protein solubility) and content of key amino acids (lysine, methionine, tryptophane, cystine, and threonine). In addition, US high-pro (dehulled) soybean meal was found to have the second-highest average crude protein level of all soybean meals analyzed. US low-pro (non-dehulled) soymeal was found to have the highest average projected digestibility of all meals analyzed as well as the lowest level of crude fiber and highest lysine and methionine levels compared to non-dehulled soymeal from Argentina, Brazil, and India.

The second best soybean meal in terms of digestibility and other major quality components appears to be the high-protein soybean meal exported by crushers in Western Europe. European meal had a high KOH level as well as low fiber and high levels of key amino acids. The fact that most of the European-origin soybean meal samples collected in this study likely were made from US soybeans is an indication that it is the superiority of US soybeans that is responsible for the superior quality of OUS and European soybean meal.

**KOH Protein Solubility**. The KOH protein solubility test is one developed to measure the relative digestibility of the protein in soybean meal and other feed ingredients. It particularly is utilized by the poultry sector to assess the quality of feed ingredients and has been shown to be a good measure of digestibility. The higher the KOH test results level, the higher the digestibility of the meal. Of the major soybean meals analyzed in the project the following is the ranking based on KOH protein solubility:

US Low-Pro Meal (85.50)
US High-Pro Meal (84.08)
European meal (82.32)
Indian meal (80.96)

Brazilian Low-Pro meal (80.64)
Brazilian Hi-Pro meal (78.98)
Argentine Low-Pro meal (76.82)
Argentine High-Pro meal (74.87)

Based on the above it is highly likely that animals fed US soymeal will digest a substantially greater share of the amino acids than they would if fed the other meals, particularly Argentine soymeals. This should continue to be a point that the USB and ASA should promote to overseas soymeal importers and users.

**Crude Protein**. Crude protein is a part of the contract under which soybean meals are purchased and is the component most important to many buyers, particularly less sophisticated buyers. While crude protein is not a reliable indication of the level of individual amino acids, it is an indication of total amino acids. The following is the ranking of the major meals analyzed in this survey:

Brazilian High-Pro Meal (48.91%)
US High-Pro Meal (48.61%)
European meal (47.79%)
Indian Meal (46.98%)
Brazilian Low-Pro Meal (46.94%)
Argentine High-Pro Meal (46.83%)
US Low-Pro Meal (45.44%)
Argentine Low-Pro Meal (44.81%)

If one multiples the average crude protein of the major types of soybean meal samples analyzed by the average KOH protein solubility level (to estimate likely digestible protein) then one finds that US high-pro and low-pro soybean meals stand out far above the other meals. The following is an indication of the estimated digestible protein levels of the major meal types.

**Table II.** Summary of Digestibility Data for Soymeal Samples

| **Characteristic** | **US Hi-Pro** | **US Low-Pro** | **Argentine Hi-Pro** | **Argentine Low-Pro** | **Brazilian Hi-Pro** | **Brazilian Low-Pro** | **Indian Meal** | **EU Meal** |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| KOH Solubility | 84.08 | 85.50 | 74.87 | 76.82 | 78.98 | 80.64 | 80.96 | 82.32 |
| Crude Protein | 48.61 | 45.44 | 46.83 | 44.81 | 48.91 | 46.94 | 46.98 | 47.79 |
| Estimated Digestible Protein Content | 40.87 | 38.85 | 35.06 | 34.42 | 38.63 | 37.85 | 38.04 | 39.34 |
| Rank | 1 | 3 | 7 | 8 | 4 | 6 | 5 | 2 |

Based on the above it would appear that US high-pro soymeal may supply as much as 5.8% more digestible protein than Brazilian high-pro soymeal and 16.6% more digestible protein than Argentine high-pro soymeal. US low-protein soymeal would appear to provide more digestible protein than all of the meals analyzed except US high-protein soymeal and EU soymeal. The worst soybean meal in terms of likely digestible protein was Argentine low-pro meal.

**Fat/Oil Content**. The meal with the highest level of fat/oil content is Argentine high-pro with an average level of 2.26%. This is not surprising considering that there is only a very small market in Argentina for soybean oil and because a higher oil level is necessary to complement the meal's lower protein content when selling into markets purchasing 48% pro-fat meal. The meal with the lowest fat/oil content is Indian meal. This also is not surprising considering that Indian crushers process soybeans primarily for their oil content with most of the soymeal being exported. US, Brazilian, and European soymeals had fat/oil contents in the middle range.

**Crude Fiber**. Crude fiber largely is indigestible by swine, and particularly by poultry. It is because of this that processors dehull soybeans to produce high-pro soymeal for sale to efficient swine and poultry producers. The following is a ranking of the fiber levels of the meals with the lowest fiber level listed first:

Argentine High-Pro meal (3.49%)
US High-Pro Soymeal (3.66%)
Brazilian High-Pro Meal (3.75%)
European Meal (3.89%)
US Low-Pro Meal (5.38%)
Argentine Low-Pro Meal (5.86%)
Brazilian Low-Pro Soymeal (5.90%)
Indian Meal (6.09%)

It is worth noting that even though it has the lowest crude fiber level, Argentine high-pro has the lowest protein content of any dehulled soymeal. This is an indication of the low average protein content of Argentine soybeans. On the other hand, the average protein content of Indian soymeal is almost 47% even though Indian meal has the highest crude fiber level. This is an indication of the high protein content of Indian soybeans. It is likely that the high temperatures that exist during India's growing season is a reason for the higher protein content.

**Amino Acids**. Amino acids are the building blocks of protein in that they are actually what swine, poultry, and aquaculture species absorb from their stomachs and utilize to produce muscle tissue. Therefore, the levels of key amino acids in soybean meal is of great importance.

The table below shows the average total amino acid levels of the major meals analyzed as well as the total of the 5 most important amino acids provided by soybean meal to swine and poultry rations. In addition, the table shows the KOH protein solubility level for each meal and an estimated amino acid digestibility derived by multiplying the amino acid levels times the KOH level.

**Table III. Key Amino Acid Content of Soymeals**

| Characteristic | US Hi-Pro | US Low-Pro | Argentine Hi-Pro | Argentine Low-Pro | Brazilian Hi-Pro | Brazilian Low-Pro | Indian Meal | EU Meal |
|---|---|---|---|---|---|---|---|---|
| Lysine | 3.04 | 2.91 | 2.86 | 2.85 | 2.95 | 2.82 | 2.92 | 2.88 |
| Methionine | 0.69 | 0.65 | 0.64 | 0.61 | 0.67 | 0.61 | 0.64 | 0.67 |
| Threonine | 1.85 | 1.75 | 1.81 | 1.73 | 1.86 | 1.76 | 1.81 | 1.81 |
| Cystine | 0.75 | 0.72 | 0.72 | 0.66 | 0.76 | 0.68 | 0.68 | 0.75 |
| Tryptophane | 0.70 | 0.66 | 0.64 | 0.63 | 0.7 | 0.67 | 0.66 | 0.69 |
| Total of above | 7.03 | 6.69 | 6.67 | 6.48 | 6.94 | 6.54 | 6.71 | 6.80 |
| Total Amino acids | 46.83 | 44.47 | 45.59 | 43.69 | 47.49 | 44.93 | 46.20 | 45.76 |
| KOH Solubility | 84.08 | 85.5 | 74.87 | 76.82 | 78.98 | 80.64 | 80.96 | 82.32 |
| Est. Digestible Total Amino Acids | 39.37 | 38.02 | 34.13 | 33.56 | 37.51 | 36.23 | 37.40 | 37.67 |
| Digestible 5 Key Amino Acid Coefficient | 5.91 | 5.72 | 4.99 | 4.98 | 5.48 | 5.27 | 5.43 | 5.60 |

The above table clearly shows that US high-pro and low-pro soymeal appear to be superior to the other major meals in terms of their absolute content of the top 5 key amino acids as well as estimated digestible total and key amino acids.  This is a likely a key reason that animals fed US soybean meal perform better than animals fed competing soybean meals.  In short, US soymeal appears to have higher levels of the key amino acids as well as a higher availability of those amino acids to animals.

John Baize
August 2, 2000