**Demeter Biotechnologies**

**Preliminary Estimates for the Value of Enhanced Protein Content in Select Feedgrains**

## INTRODUCTION / METHODOLOGY

The objective of this opportunity scan is to provide Demeter with an initial indication as to the market potential and receptivity to protein-enhanced crops currently under development.

To accomplish this objective, we held interviews with livestock nutritionists, feed company representatives, industry observers and academia. We selected from this group three different nutritionists to help run scenarios to determine the estimated "opportunity prices" or values for enhanced-protein crops used in standard rations. Some of the detail from these calculations is included below. The analysis developed by these nutritionists has been somewhat simplified from the normal linear programming they would conduct.

These values should be considered "order of magnitude" estimates designed only to give direction and a more refined focus for the next level of investigation necessary to fully understand the potential of this technology.

In order to develop these values, some simplifying assumptions were made - critical in performing the analysis. These included:

- Agronomic yields for these crops (corn, soybeans, and wheat) are assumed not to be reduced or not significantly reduced from current average expected yields.
- When raising the crude protein levels in the selected crops, it was assumed that there was a balanced or proportionate increase in amino acids -- an aggressive assumption.
- For soybeans, we assumed there is not a significant decrease in the oil content as protein levels rise. If there is, this will diminish the value of enhanced-protein soybeans, as the economics of soybean oil are much more attractive to a processor than meal – meal is almost a by-product currently, e.g., oil is selling at $0.28 / lb. while meal is about $0.07 / lb.
- We assumed the quality of the protein, e.g., its availability and digestibility to the animal remains the same. This is also a critical assumption because while particular amino acids may have increased in content, they may not be fully available (digestible) to the animal.

- We assumed the quality of the crop remains unchanged, e.g., there have been some problems with high lysine corn in that it was mealy and difficult to handle by feed manufacturers.

- Other assumptions used to develop the modified rations and resulting values are listed next to the analysis below.

- The nutritional analyzes performed in this draft report are based on commodity crop prices today, and are subject to change on a daily basis, hence the value of the technology could be over or understated. A more concise analysis is required which would incorporate historical grain, feed and animal prices to more accurately predict technology values.

**All these assumptions must become components for additional research and investigation.**

This analysis focused on the potential value of enhanced protein levels in crops fed to poultry and swine (mono-gastric animals) beef (ruminant), and wheat for flour milling purposes. If so desired, we can calculate the potential values for dairy nutritional value as well.

## KEY LEARNINGS

Initial discussions with livestock nutritionists and other industry experts indicated a "curious interest" in enhanced-protein crops. All interviewed said that if our primary assumptions hold true, the implications for this technology could be "enormous" and "far reaching." The concept would be "extremely well received" from all major livestock sectors, but particularly from the poultry and pork sectors.

Nearly all interviewed spoke of the increased level of interest and activity in developing "designer" crops tailored to meet specific livestock nutritional needs. Interestingly two nutritionists we called to request their assistance on this assignment declined due to a conflict of interest – they were assisting other life science companies in very similar projects.

All animal feeding is driven by the Least Cost Ration method. This strategy is designed to choose the required nutrients at the lowest possible costs. This formulation method requires changes and adjustments almost weekly in some instances, due to price changes. In the case of protein, the US is a low cost source of protein for livestock feeding (soybeans, animal by-products, etc.). Most interviewees suggested that enhanced protein corn would have the most value in a situation where the commodity price of alternative protein was high, so both energy and protein could be delivered in one grain.

*For any new transgenic crop, the ultimate ability to capture value from inclusion in livestock feeding systems rests on not only its performance but on the economics of alternative sources of required nutrients.*

Integrators like Tyson and Murphy Farms are adjusting rations almost weekly in cases where alternative protein and energy sources have dropped in price (as long as the changes do not affect animal performance and quality).

One of the major benefits of enhanced-protein grains is the quality of that protein can be assured – unlike some by-products used for protein, where the quality is questionable. The other major benefit for larger integrators with enhanced protein grains is that a price could be "locked in" for an extended period. Nutritionists and commodity buyers can spend less time searching for alternative nutrient sources and have a more consistent ration throughout the life of the animal.

Below are summary comments and preliminary value estimates for the poultry, swine and beef feeding sectors. Comments on dairy from nutritionists are also attached.

***Poultry:***

- Probably the most critical factor in poultry nutrition is the amino acid balance / composition and availability of those amino acids, particularly methionine and lysine.
- "We poultry nutritionists don't give a damn about crude protein!"

Some of the key issues / questions poultry industry experts raised in discussing the possible technology included:

- "Total protein is cheap – what are the particular amino acid levels?"
- What is the energy value?
- What is the quality of the grain? Will it crumble in the manufacturing process?
- Are there yield differences? Will this crop require additional or different fertility requirements?
- Will the grains be pest resistant?

Some thought enhanced protein would become one of the "stacked" traits of identity preserved feedgrains, along with guaranteed higher levels of particular amino acids, energy (oil), etc.

The following summary analysis provides an order of magnitude of the value of higher protein corn for broilers to the feed manufacturer (combined starter, grower and finisher rations).

Some of the assumptions used to calculate this analysis include:

- Production of a five pound bird in straight run (50:50 males / females) 20,000 sq. ft. house (22,000 birds / house) at 80 degrees F.
- Final numbers show a combination of starter, grower and finisher diets.
- The model used by this nutritionist calculates the cost of the meat produced, not final feed or production costs.

### ESTIMATED PRELIMINARY VALUES OF HIGH PROTEIN CORN IN A BROILER RATION

| % Crude Protein | Value / Bu. | % Incremental Improvement |
|---|---|---|
| 7.9% | $0[1] | 0 |
| 9.9 | +0.17 | 5.1% |
| 11.9 | +0.32 | 4.4 |
| 13.9 | +0.47 | 4.2 |

### ESTIMATED PRELIMINARY VALUES OF HIGH PROTEIN SOYBEANS IN A BROILER RATION

| % Crude Protein | Value / Bu.[2] | % Incremental Improvement |
|---|---|---|
| 48.5% | $0 | 0 |
| 51.0 | +9.0 | 8.6% |
| 53.6 | +18.8 | 9.8 |
| 56.3 | +28.0 | 10.0 |

Some of the conclusion of this modeling suggests:

- Using a 13.9% protein corn, under these initial assumptions, could save a broiler complex with 1.2 million five pound birds approximately $0.0003 / lb. or $724,000 per year.
- If 9.9% crude protein were priced at the same point as 7.9% corn, the complex would save $1.45 million / year.

[1] Base is $3.27 / bu.
[2] Base is $246 / T

- The value of enhanced protein corn is greatest in the starter and grower diets, where protein is critical, versus the finisher ration.

A second analysis conducted by another poultry nutritionist found strikingly similar results on a percentage basis:

This analysis broke out the starter, grower and finisher rations. Protein requirements for these rations as recommended by industry are 23%, 20% and 18% respectively.

Prices for corn and beans varied from the first analysis: $3.08 for corn and $197 / T for soybean meal.

The results are summarized below in cost / ton of feed in a broiler starter ration:

*% Protein, SBM*

| % CP. Corn | 48.5% | 50% | 51% | 52% | 53% | 54% | 55% |
|---|---|---|---|---|---|---|---|
| 8.9% | $147.55 | $146.91 | $146.43 | $145.61 | $144.84 | $144.1 | $143.74 |
| 10.0 | 145.26 | | | | | | |
| 10.9 | 143.27 | 142.71 | 142.26 | 141.75 | 141.02 | N/C | 140.01 |
| 12.0 | 141.00 | | | | | | |
| 12.9 | 139.01 | 138.28 | 137.79 | 137.29 | 136.76 | N/C | 135.85 |
| 14.0 | 136.50 | | | | | | |
| 14.9 | 134.39 | 133.59 | 133.07 | 132.82 | 132.55 | N/C | 132.5 |
| Percent Savings 8.9-14.9% | 9.4% | 10% | 10% | 9.6% | 9.3% | N/C | 8.5% |

Similar tables for grow our and finishing feeds found the following summary savings percentages:

| | 48.5% | 50% | 51% | 52% | 53% | 54% | 55% |
|---|---|---|---|---|---|---|---|
| Percent Savings 8.9-14.9% | | | | | | | |
| Grow-out | 4.6% | 4.0% | 3.7% | 3.2% | 2.8% | 2.4% | 2.2% |
| Finisher | 0.8 | N/A | N/A | N/A | N/A | N/A | N/A |

These preliminary numbers support the finding that the greater value for enhanced-protein grains are found when fed to younger animals. Birds in the finishing stage (about 10-12 days) require significant energy to add weight, not grow.

Also, feeding a higher protein content soybean meal and a higher protein corn diminish the value of the additional protein, due primarily to the cost of soybean meal.

It should be noted that while all nutritionists mention the importance of particular amino acids in the diet, the actual volume of key synthetic amino acids added in the ration to supplement deficiencies in grains is minimal, e.g., in a typical broiler ration methionine makes up about 0.2% of the volume and in a swine ration, about 0.15% of the ration is lysine.

*Beef:*

- Feeding strategies are based almost entirely on energy – adding weight as fast as possible in the finishing portion of the animals life.
- In the finishing stages, protein is not a critical determinant in ration development.
- Ruminants are able to digest Non-Protein-Nitrogen (NPN) (usually urea) and convert it to protein easily.
- Protein content is important in the growing stages of the animal -- this is true for all species, and where the greatest value of the technology may lie.

To calculate the value of enhanced-protein grains for beef cattle finishing the following assumptions were used:

- Protein was increased two percentage points in corn, and wheat. Soybeans are not normally fed to beef cattle, and wheat is fed only when the corn / wheat price ratio is economical.
- It was assumed that as the protein levels in the grains increased, the energy levels decreased (about a 1% decrease for every 2% increase in protein).
- Cattle economics were ignored in the analysis, i.e., cattle prices
- The calculations show 13% protein (DM) finishing diets with corn and wheat at the different protein levels and the effect on supplemental protein needs. The value then becomes the reduction in protein needs from supplements.

The following table shows the different protein levels of corn in a standard ration and what happens to required supplements (alternative protein sources) to arrive at a cost / Bu of feed:

| Ingredient | % in Ration | 8.5% | 10.5% | 12.5% | 14.5% |
|---|---|---|---|---|---|
| | | Cost / 100 lbs. feed. | | | |
| | | | | | |
| Corn[3] | 67% | $3.39 | $3.39 | $3.39 | $3.39 |
| Corn silage | 20 | 0.35 | 0.35 | 0.35 | 0.35 |
| Alfalfa hay[4] | 5 | 0.25 | 0.25 | 0.25 | 0.25 |
| Protein Cost[5] | 8 | 0.40 | 0.12 | 0.06 | 0.00 |
| Total | 100% | $4.38 | $4.10 | $4.05 | $3.99 |

We then incorporated these feed costs to calculate the value in a diet fed to beef cattle:

Protein Percent in Corn

| | 8.5% | 10.5% | 12.5% | 14.5% |
|---|---|---|---|---|
| Weight In | 700 | 700 | 700 | 700 |
| Weight Out | 1200 | 1200 | 1200 | 1200 |
| Intake, lbs. / da. | 25 | 25 | 25 | 25 |
| Average Daily Gain | 3.05 | 3.01 | 2.97 | 2.92 |
| Feed / Gain, Dry Basis | 6.22 | 6.31 | 6.41 | 6.5 |
| Days on Feed | 164 | 166 | 169 | 171 |
| Cost / lb. Ration | $0.438 | $0.041 | $0.0405 | $0.0399 |
| Cost of Gain | $0.2724 | $0.2587 | $0.2596 | $0.2593 |
| Corn Needed / lb. Gain | 4.16 | 4.22 | 4.29 | 4.35 |
| Extra "Value" of Corn / Bu. | $0 | $0.13 | $0.07 | $0.01 |
| "Value" of Corn / Bu. | $2.83 | $2.96 | $2.90 | $2.84 |
| Percent "Value Increase" | | 4.49% | 2.35% | 0.32% |

[3] Priced at $2.83 / Bu (4 May price)
[4] Priced at $100 / T
[5] Urea (288% protein at $180 / T) and soybean meal (44% at $162 / T). Supplement held constant to compare grain on an equal basis into the ration. If adjusted, other components would adjust, and linear programming would be required.

The same analysis for wheat fed to beef cattle found the following:

| Ingredient | % in Ration | 12% | 14% | 16% | 18% |
|---|---|---|---|---|---|
| | Cost / 100 lbs. feed. | | | | |
| Wheat[6] | 67% | $3.56 | $3.56 | $3.56 | $3.56 |
| Corn silage | 20 | 0.35 | 0.35 | 0.35 | 0.35 |
| Alfalfa hay[7] | 5 | 0.25 | 0.25 | 0.25 | 0.25 |
| Protein Cost[8] | 8 | 0.40 | 0.12 | .06 | 0.00 |
| Total | 100% | $4.56 | $4.28 | $4.22 | $4.16 |

Protein Percent in Wheat

| | 12% | 14% | 16% | 18% |
|---|---|---|---|---|
| Weight In | 700 | 700 | 700 | 700 |
| Weight Out | 1200 | 1200 | 1200 | 1200 |
| Intake, lbs. / da. | 26 | 26 | 26 | 26 |
| Average Daily Gain | 3.09 | 3.04 | 2.96 | 2.91 |
| Feed / Gain, Dry Basis | 6.52 | 6.61 | 6.8 | 6.9 |
| Days on Feed | 162 | 164 | 169 | 172 |
| Cost / lb. Ration | $0.456 | $0.0428 | $0.0422 | $0.0416 |
| Cost of Gain | $0.2973 | $0.2829 | $0.2870 | $0.2870 |
| Wheat Needed / lb. Gain | 4.16 | 4.22 | 4.29 | 4.35 |
| Extra "Value" of Wheat / Bu. | $0 | $0.12 | $0.06 | $0.01 |
| "Value" of Wheat / Bu. | $3.19 | $3.31 | $3.25 | $3.20 |
| Percent "Value Increase" | | 3.81% | 1.97% | 0.27% |

What does all this mean for beef cattle feeding?

- The most additional value came from the smallest increase in total protein.
- The extra protein does not significantly increase the value of the grains for cattle feeding.
- The grains are primarily used for energy and the extra protein decreases the energy value by about 1% for each two units of protein increase.
- The driver in using / adopting enhanced-protein grains in beef feeding is the price of urea.

[6] Priced at $3.19 / Bu (4 May price)
[7] Priced at $100 / T
[8] Urea (288% protein at $180 / T) and soybean meal (44% at $162 / T)

The rumen (stomach) in cattle have bacteria which require non protein nitrogen or a soluble protein to survive. These bacteria then convert NPN to required protein. Urea is a relatively cheap source of NPN. According to nutritionists, the perfect set of amino acids is not know for ruminants, but if they were supplied by a protein-enhanced grain, the amino acids or protein would have to by-pass the rumen to be effective or the bacteria will change the protein into nitrogen and re-form the protein.

*Pork:*

- Similar nutritional requirements to poultry, e.g., proper amino acid balance (lysine more important to swine than poultry).

- One swine nutritionist estimated that savings in the range of $12-20 / Ton could be realized with the reduction of soybean meal. He predicted that the true selling value would come in increased levels of lysine.

- Reducing the levels of SBM, assuming all the required amino acids are increased in the corn, does not affect the nutritional quality of the ration. "There is no secret or special function associated with SBM other than its protein value."

- He questioned whether soybean crushers would want to handle the product, as it is likely oil content will decline with increased protein levels, and oil is more valuable to the crusher.

The nutritionist calculating values in swine rations did the following:

- Instead of actually switching lower protein corn and beans for higher protein ingredients, minimum energy, amino acids (lysine in particular) and protein requirements were fixed.

- In the same model, the higher protein grains were available, and could be selected by the program if the minimum nutrient requirements were met. Summary results follow:

- In the standard run, energy and lysine minimums (pressure) were established (typical swine ration), with no pressures (minimums) on protein:

| Corn Protein % | Value Increase | SBM Protein % | Value Increase |
|---|---|---|---|
| | | | |
| 10.5% | +0.002% | 50% | 1% |
| | | | |
| 12.5% | +0.003 | 52 | 2.3 |
| | | | |
| 14.5% | +.006 | 54 | 2.6 |

Higher levels of protein in corn showed minimal additional value when the ration was selected for energy and lysine.

For soybean meal, there was a slightly higher value attached to the increased protein, as SBM adds energy as well as protein.

The greatest value for the grains appeared when pressure (minimums) were set on protein, energy and lysine, which would be done in a starter / grower ration:

| Corn Protein % | Value Increase | SBM Protein % | Value Increase |
|---|---|---|---|
| 10.5% | +2.3% | 50% | +1.4% |
| 12.5% | +4.6 | 52 | +2.7 |
| 14.5% | +7.0 | 54 | +3.2 |

There was some incremental additional value beyond the above numbers when pressure was released on energy.

In summary:

- The potential reduction in energy resulting from increases in protein reduced the value of the corn. The increased levels of amino acids could not overcome the reduction in energy.
- Restrictions (minimums) on energy and amino acids resulted in the higher protein soybean meal having the greatest value.

As was pointed out previously, as protein in the grain increases, energy content decreases. This causes the animal to consume more, thus reducing the feed to gain ratio, resulting in increased costs to the producer. An ideal grain would increase both proportionately.

*Dairy:*

Some general comments on dairy nutrition / requirements:

- In dairy as in beef cattle, much of the required protein is broken down in the rumen and the nutritional value is lost. By-pass protein (protein which passes through the rumen into the lower digestive tract and is absorbed) is critical to sustaining high milk production in dairy cows.

- Ingredients with high by-pass protein values include chopped, ensilaged hay at 20%, shelled corn at 50% and meat / bone and blood meal at 60+%. There are some new products available to dairy producers like heat-treated soybean meal with high by-pass protein, which have gained acceptance in the last five years.

- Feeding, more than any other single factor determines the productivity of lactating dairy cows. Approximately 75% of the differences in milk production between cows is determined by environmental factors, with feed making up the largest portion. Feed also represents about 55-60% of the total costs of milk production, therefore a sound and nutritionally balanced ration is critical.

- There is much more variation in the protein content of a dairy cow's ration because many dairy operations still rely on forages as the primary feedstuff.

- Dairy cattle are fed rations high in energy and protein to supplement forage intake. Protein content is normally in the 17-20% range.

Preliminary estimates for additional nutritional value from enhanced-protein grains fed to dairy cattle ranged from 2% to 5%, assuming the additional protein is not broken down in the rumen and is digestible in the lower GI tract.

## Estimated Value of Additional Protein in Select Grains Fed to Livestock

The following table uses the protein value of soybean meal (44% at $162 / T equals $0.1841 / lb.) to determine the relative value of enhanced-protein grains. This is not meant show the value in feeding livestock, but to illustrate the additional value of the protein based on a soybean meal price.

| | % Protein | Pounds of Protein / T | Value of Protein / T @ $0.18 / lb. | Value of the Grains | Percent Increase Over Normal Protein |
|---|---|---|---|---|---|
| | | | | | |
| Corn | 8.5% | 170 | $31.3 | $101.07 | |
| | 10.5 | 210 | 38.66 | 108.44 | 7.29% |
| | 12.5 | 250 | 46.02 | 115.8 | 14.57 |
| | 14.5 | 290 | 53.39 | 123.16 | 21.86 |
| | | | | | |
| Wheat | 12% | 240 | $44.18 | $106.33 | |
| | 14 | 280 | 51.55 | 113.7 | 6.93% |
| | 16 | 320 | 58.91 | 121.06 | 13.85 |
| | 18 | 360 | 66.27 | 128.42 | 20.78 |
| | | | | | |
| Soybeans | 38% | 760 | $139.91 | $213.67 | |
| | 40 | 800 | 147.27 | 221.03 | 3.45% |
| | 42 | 840 | 154.64 | 228.39 | 6.89 |
| | 44 | 880 | 162.00 | 235.76 | 10.34 |

While this table shows some attractive values for enhanced-protein grains, as was illustrated in beef and poultry, the values can change when factors such as energy content, feed conversion rates and prices of other competing proteins are considered.

## High Oil Corn (HOC) as a Potential Model:

Commercially introduced in 1996, high oil acreage is reportedly reaching 2.5 mil acres of production, with projections for 5.0 mil in 1999. HOC has a larger germ than conventional yellow dent corn. This germ portion of the kernel is richer in fat and protein, including a higher concentration of lysine, and oleic acid, energy.

*Grain comparison:*

| | Normal Corn | High-Oil Corn |
|---|---|---|
| Protein Content | 8.0-8.5% | 9.0-9.5% |
| | | |
| Oil Content | 3.5 | 5.0-6.0 and reported to be higher quality than alternative fat sources |
| | | |
| Energy Content | 1,560 Kcal / lb. | 1,630 Kcal / lb. |
| | | |
| Methionine / Lysine | 0.18 / 0.26 | +5-8% |
| | | |
| Yields | 145 | About the same, but requires planting populations about 10% more than normal hybrids to accommodate pollinator plants. |

To date, reactions among all livestock sectors feeding HOC has been mixed. HOC has its major advantage in that it increases energy and protein content at the same time. Recent research also suggests amino acids such as lysine is more available to the animal that conventional corn.

The most challenging aspect of HOC has been the inability to properly segregate the corn, and ensure customers that what they are paying a premium for is actually HOC.

Growers typically receive a premium of $0.20-0.30 / Bu, but pay in the range of $25-35 / bag extra for the seed, plant more seeds, and experience slightly lower yields. *A key component of the next stage of investigation is a determination of farm-level economics of enhanced-protein grains.*

The advantage high-protein crops could have over HOC is that it is difficult to determine the oil content of the grain quickly. Measuring protein is relatively easy and quick.

Reportedly, Continental Grain has seen its export sales of high oil corn increase at a much faster rate that domestic sales because oil and protein sources are scarce and costly overseas. However the one factor which may change the economics slightly in the US is the increasing interest in non-animal protein and energy sources. Driven by the BSE factor, many feed manufacturers are searching for alternative protein and energy sources to animal by-products, e.g., lard, blood and meal by-products. These and other feed ingredient regulation may enhance the value of transgenic crops with enhanced protein levels.

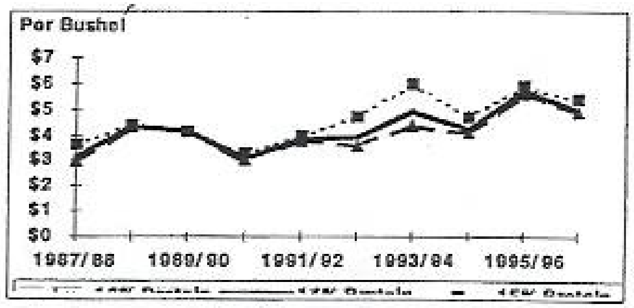
## SUPPORTING INFORMATION ON CROP SIZES, VALUES AND UTILIZATION

The following section provides Demeter with the size and scope of some of the target crops for the technology, preliminary estimates for utilization of these crops by livestock species and estimated potential values of enhanced protein grains for select species. As these are preliminary numbers, more refinement is required to determine more precise market size estimates.

### Wheat:

One of the crops which has historically valued additional protein (and reported that value) is wheat for food uses. Standard flour will contain 11% protein. Protein content can reach as high as 17%, unblended. To achieve higher levels, users of flour will blend different flours or add vital wheat gluten to the mix. The addition of vital wheat gluten is a very economical and prevalent method of boosting protein levels.

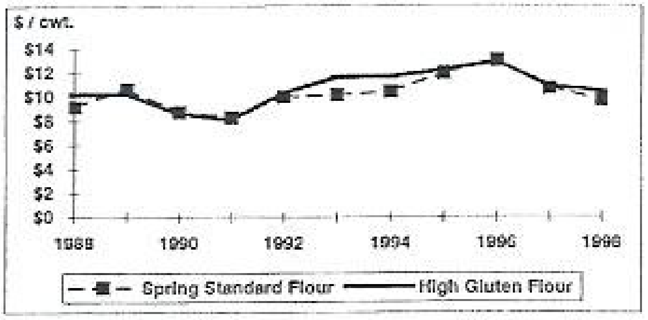
Historical values of additional protein in wheat




Over the last ten years, the average protein differentials for higher protein wheat were:

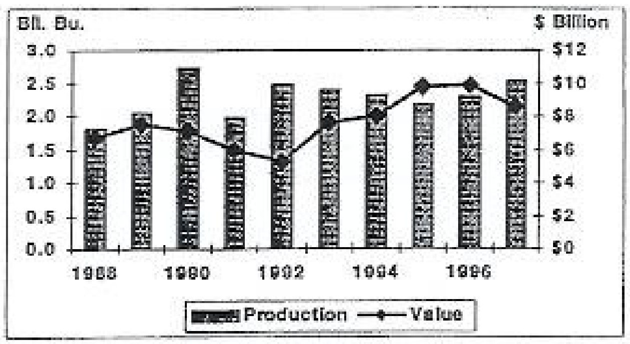
- Approximately $0.15 / Bu. for 14% wheat over 13% wheat
- Approximately $0.40 / Bu. for 15% wheat over 14% wheat
- While not common, wheat as high as 17% protein content can be found, and reaches as high as $6.15 / bu. (1996), a premium of over $1.25 from 13% wheat during that same year.

The following chart looks at historical values of high protein flour versus standard flour:




Over this 10 year period the average price differential for high gluten (high protein) flour was $0.39 / cwt.

The total wheat crop last year was approximately 3.0 bil. bushels. Of that, roughly 45% was exported, with the remained used in food (915 MM bu) (45%), feed (310mm bu) (15%) and other.

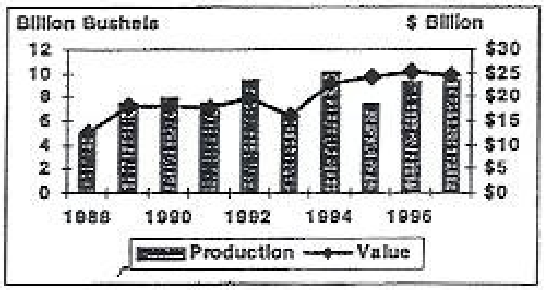



Assuming an average protein premium from all protein levels in all classes of wheat of $0.60 / bu, and applying that to the percent of the US wheat supply consumed by humans, the initial market opportunity for enhanced protein wheat for food usage could be in the range of $500-$600mil. at the first stage processor level (flour miller purchases).

While the historical data suggests attractive protein premiums, further investigation is required to determine what the implications on future premiums are if a large percent of the wheat crop is planted as higher protein varieties. This sector is highly complex, e.g., pricing, producer-planting decisions, importance of gluten as a protein alternative, functional demands of the food sector, and further clarification is warranted.

**Corn:**

The total corn crop in the US last year equaled nearly $25 bil. or nine Bil. bushels. Of that, approximately 55% was fed to livestock.




The following simplified analysis is meant only to provide an order of magnitude of the opportunity for enhanced-protein corn by livestock species.

To determine preliminary market opportunity values for high-protein corn fed to poultry, the following assumptions were made:

- Broilers consume 10 lbs of feed to reach a finished live weight of five pounds. Of this feed, about 70% is corn.
- Approximately 7.76 bil. broilers were produced in the US in 1997.
- Total corn consumed by broilers thus, is estimated to be 5.4 bil pounds or 970 mil bu. (this excludes feed consumed by breeder stock

If the potential increase in the value of high protein corn is between 4% and 10% and the average corn price is $3.00 then the additional value (not price) to poultry operations is $116 to $291 mil.

To determine preliminary market opportunity values for high-protein corn fed to swine, the following assumptions were made:

- A hog consumes approximately 682 lbs of feed over its entire life. Of this feed, 70% is corn.
- Approximately 92 mil. hogs were slaughtered in the US in 1997.

- Total corn consumed by swine, thus is estimated to be 4.3 bil. pounds or 784 mil bu. (this excludes feed consumed by sows and boars)

If the potential increase in value of high protein corn is between 2% and 7% and the average corn price is $3.00 then the additional value (not price) to pork operations is $47 to $164 mil.

To determine preliminary market opportunity values for high-protein corn fed to beef, the following assumptions were made:

- Cattle in their finishing stages (700 lbs in, 1200 lbs. out) consume approximately 3,000 lbs of fee. Of this feed, 67% is corn.
- Approximately 28 mil. beef cattle were slaughtered in the US in 1997 (this excludes breeding stock and fed dairy cattle).
- Total corn consumed by grain fed beef cattle is 5.6 bil. pounds or 1.0 bil. bu.

If the potential value of high protein corn is between 0.3% and 4.5% and the average corn price is $3.00 then the additional value (not price) to cattle finishing operations is $9.0 mil to $130 mil.

Estimated Size of the World Seed Corn Market

| | Est. Acres Planted, MM | Assumed Seeding Rate | Est. Price / Bag Seed | Est. Value, $ Bil. |
|---|---|---|---|---|
| | | | | |
| US | 80 | 28,000 seeds / acre[9] | $75[10] | $2.1 |
| | | | | |
| ROW | 265 | 28,000 seeds / acre | $75[11] | 7.1 |

**Note:** While there are many more acres of corn planted in the ROW compared to the US, yields are considerably less than the US, therefore the resulting crop and its potential additional value is significantly diminished.

[9] Assumes 2,000 seeds / lb.
[10] 80,000 seeds / bag
[11] Most likely this value is overstated, particularly in areas of the world where low yielding corn and other crops are planted (in some cases, non-hybrids).

Estimated Size of the World Soybean Seed Market

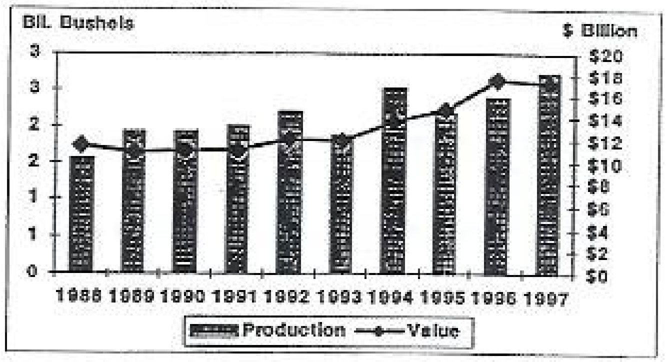
| | Est. Acres Planted, MM | Assumed Seeding Rate | Est. Price / Bag Seed | Est. Value, $ Bil. |
|---|---|---|---|---|
| | | | | |
| US | 70 | 180,000 seeds / acre[12] | $25 / 50 lb. bag | $1.9 |
| | | | | |
| ROW | 96 | 180,000 seeds / acre | $25 / 50 lb. bag | |

Estimated Size of the World Wheat Seed Market

| | Est. Acres Planted, MM | Assumed Seeding Rate | Est. Price / Bag Seed | Est. Value, $ Bil. |
|---|---|---|---|---|
| | | | | |
| US | 71 | 1.25 to 1.5 bu. / acre | $8.00 / bu. | $0.78 |
| | | | | |
| ROW | 489 | 1.25 to 1.5 bu. / acre | $8.00 / bu. | 5.3 |

**Soybeans:**

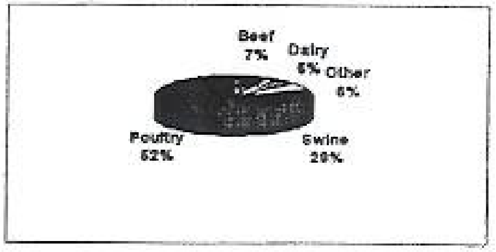
The US produced a record 3.0 Bil bushels of soybeans last year, valued at just over $18 Bil. Approximately 55-60% of this production was crushed domestically producing 34MM tons of meal for livestock feeding.



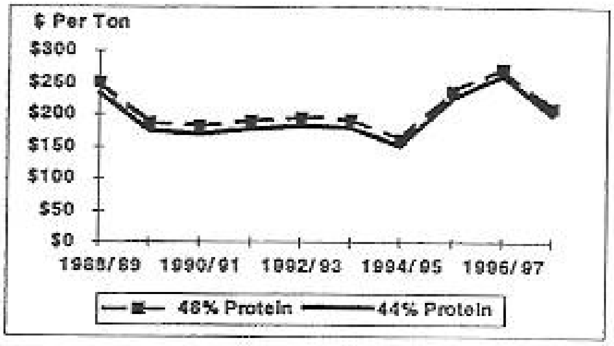

12 Assumes 2,600 seeds / lb.

The majority of this tonnage was fed to poultry and pork . . .

Estimated Soybean Meal Usage by Livestock Species[13]




Soybean meal pricing is dependent on protein content (there are two protein meals, 44% and 48%) and supply of these meals is based on a decision by the oilseed crusher to crush for more or less oil, based on market conditions.




Historically, the price spread (margin) between 48% and 44% soybean meal has about $0.15 / pound or $0.04 / protein point.

The following simplified analysis shows the potential value of enhanced protein soybeans fed to poultry and swine.

To determine preliminary market opportunity values for high-protein soybean meal (SBM) fed to poultry, the following assumptions were made:

- ☐ Broilers consume 10 lbs of feed to reach a finished live weight of five pounds. Of this feed, about 20% is SBM.

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[13] Source: United Soybean Board

- Approximately 7.76 bil. broilers were produced in the US in 1997.
- Total SBM consumed by broilers thus, is estimated to be 7.8 mil. tons of SBM (this excludes feed consumed by breeder stock

If the potential increase in the value of high protein SBM is between 8% and 10% and the average SBM price is $180 / t then the additional value (not price) to poultry operations is $112 to $140 mil.

To determine preliminary market opportunity values for high-protein SBM fed to swine, the following assumptions were made:

- A hog consumes approximately 682 lbs of feed over its entire life. Of this feed, 25% is corn.
- Approximately 92 mil. hogs were slaughtered in the US in 1997.
- Total SBM consumed by swine, thus is estimated to be 7.8 mil tons (this excludes feed consumed by sows and boars)

If the potential increase in value of high protein SBM is between 1.4% and 3.2% and the average SBM price is $180 / T then the additional value (not price) to pork operations is $20 to $45 mil.

***Issues related to Identity Preservation:***

Crops designed with particular traits desirable to some end-user have been grown under contract production for many years. Crops like waxy-corn, high in starch content for industrial usage and corn with oil content desired by Frito Lay are two examples. These crops require segregation from the commodity system to ensure the customer is getting the proper grains. Systems have been established to manage the logistics of "identity preserved" grains, but for the most part, these volumes have been small enough that logistics and segregation has not been a major challenge.

Recently however, the increase in IP crops due to biotechnology has released more crops with particular traits in larger volumes, e.g., high oil corn. Increased volume has placed heavy demands on the system – one of the new challenges is testing grains to ensure integrity. Wet chemistry techniques can require a testing period of about one-week – unacceptable to feed manufacturers requiring quick decisions.

Near-infrared technology (NIR) is just now being implemented at the buyers locations, e.g., Jeanie-O, a large poultry operation just installed NIR technology at their mills to ensure what they are buying is in fact high oil corn. Some believe in the near future combines will be fitted with this technology to achieve real-time nutrient analysis.

Another challenge facing HOC is storage capacity at the end-users facilities. Many integrated poultry and swine operations are not set up to receive different batches of IP grains. Many in the poultry industry believe that in the next few years, integrators such as Tyson and Murphy Farms will begin to contract with elevators directly to manage grain supplies, including IP related issues.

The larger issue facing all IP crops is their performance at the farm. Producers want to achieve yields as high if not higher for these crops. If yields cannot be achieved, producers will want higher premiums to compensate for lower yields.

A key to the success of enhanced-protein crops is their ability to meet or exceed yields to achieve adoption by the grower community and then "mark" these crops (through color systems or other means) to ensure integrity of the crop.

## CONCLUSIONS / STRATEGIC RECOMMENDATIONS

Overall, the concept of increased protein content was well received by nutritionists, feed manufacturers and livestock economists.

Many technical and market-related issues remain. For example:

- Does this protein enhancement proportionately increase amino acids and other critical nutrients, and are they available to the animal?
- What is the agronomic performance potential of grains with enhanced protein traits?
- Can our other major assumptions hold true?
- What are the issues related to identity preservation and can they be solved?
- What are the economic implications at the production level?
- Will this technology reduce the premiums currently offered for protein long-term?
- Are there animal nutrition companies who could serve a "launch partners" for this technology?

One nutritionist commented that the maximum premium value is always achieved at the first increment of use. A genetically enhanced ingredient may have a premium value of $30 / T when it replaces 25% of an existing ingredient, but this premium may drop to $15 / T when it replaces 50% of an existing ingredient.

Additional work is needed to determine how to best introduce this technology, e.g., who would be optimal grain handling entities or integrated livestock operations that could serve as alliance partners in managing this identity preserved crop?

Partnering with companies in the life sciences, agricultural inputs and grain handling / distribution will serve to create the supply chain necessary to introduce this technology to the market.

**Other considerations / possibilities for additional investigation:**

While not the focus of this preliminary analysis, it is worth noting that there could be additional opportunities for this technology in areas such as corn for human consumption. Many third-world countries are nutritionally deficient in protein, but consume significant quantities of corn, e.g., Central and South America. Increasing protein content in corn could be valuable to this segment.

Rice is another human food fed to a large portion of the world's population which is also protein deficient. The ability to enhance protein content for this crop could provide much-need additional protein. The primary question for both of these examples becomes is the market willing to pay additional premiums for additional protein?

Finally, an area in which Demeter has completed much work is potatoes. While livestock feeding applications are limited with this crop (the exception is feeding potato processing waste and cull potatoes), there could be significant value to potato processors if the level of total solids were increased in the crop.

We believe the market potential for protein-enhanced crops could be substantial to Demeter. Additional technical and economic analysis must be conducted to prove or disprove these preliminary findings and our assumptions. However, the concept of protein enhancement is attractive to the animal feeding and human foods markets and there are other organizations evaluating the opportunities as well.

## General Livestock Nutrition Definitions

Crude Protein – the content of nitrogen in a feed or animal tissue or excreta, multiplied by a factor (usually 6.25 since most proteins contain about 16%N) to provide an estimate of protein content (both non-protein N (amino acids, amines, ammonia, etc.) and true protein may be present.

Non-Protein Nitrogen (NPN) – nitrogen originating from other than an amino acid source but may be used by bacteria in the rumen to synthesize protein. NPN sources include compounds like urea and anhydrous ammonia, which are sued in feed formulations for ruminants (cattle, sheep).

Energy Value- the quantity of kilocalories / kilogram of metabolizable energy available to the animal. Energy can come from carbohydrates, protein or fat (the greatest from fat).

Essential Amino Acids – amino acids which are needed for animal metabolism but cannot be synthesized by the animal in the amount needed and thus, must be present in the diet of that animal.

Quality of Protein – refers to the amount and ratio of essential amino acids present in a protein. A protein is said to be of good quality when it contains all the essential amino acids in proper proportions and amounts needed by specific animals.

By-Pass Protein – essential amino acids, which are left, undigested by the rumen (stomach) and pass to the small intestines where they are absorbed.