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Economics of Soybean Biotechnology in the Livestock Industry

ABSTRACT: Using a linear programming model, this study evaluates the effects of commercializing new biotech-soybean varieties on the livestock producers' feed costs and formulations. Major findings include: (1) development of new alternative soybeans would benefit poultry meat producers more than egg and pig meat producers; (2) new soybean meals would save more feed costs in starter diets than in either grower or finisher diets; and (3) economic advantages of new soybean meals were highly sensitive to the availability of alternative protein sources but less sensitive to changes in ingredient prices.

INTRODUCTION

New techniques of biotechnology are increasingly available to create more desirable products for end-users. The new techniques applied to soybean breeding and genetics greatly increase the possibility of developing high-quality soybeans for various uses. Numerous studies have reported that soybeans can be genetically tailored to meet market needs and that these specialty soybeans have great potential for increasing the value of soybean products, particularly in the livestock industry (e.g., Scott, Lago, and Nielsen, 1991; Shoemaker and Diers, 1991). For example, higher protein soybeans or those with higher combinations of particular essential amino acids (e.g., lysine, methionine, and tryptophan) are expected to greatly reduce the feed costs of targeted livestock groups. Although these modified soybeans are increasingly demanded by both domestic and foreign livestock producers, few studies have analyzed the poten-

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tial effects on the livestock industry of commercializing these high-quality soybeans.

A recent study conducted by a task force of Iowa State University scientists and outside consultants projected the possible types of soybean modifications and provided the economic implications of these modifications (Greiner, 1990). Although the Iowa study provides useful guidelines for the estimation of economic impacts of soybean biotechnology, it does not include sufficient information about how much end-users of these technologies, primarily livestock producers, would benefit from these innovations. For instance, the previous research estimated the benefit of each alternative technology from only one optimal ration (mainly starter) for each livestock group and generalized this value for the whole growth period. However, the benefit to livestock producers obtained from increased quality characteristics may be different by growth stage of each livestock group because nutrient requirements used in least-cost formulations differ by growth stage.

Other studies related to the economic evaluation of soybean biotechnology include McVey, Pautsch, and Baumel (1995) and Chung and Buhr (1997). Unlike the previous research (Greiner 1990), these studies focused on the analysis of market-level effects, evaluating effects of modified soybeans on the related industries. Market equilibrium models were used with elasticities of demand and supply for each industry and technology shifters of new soybeans. The technology shifters were either compiled from previous research or directly estimated as per unit feed-cost reduction from optimal feed formulations. Although the analysis of market-level effects at aggregate levels provides useful information to policy makers and public researchers, individual business units in the livestock industry might be more interested in the details of how much they could save on their feed costs and how the soybean biotechnology would change their least-cost feed mix. Further, although technology shifters play a significant role in determining the size of benefits from modified soybeans, the validity of these shifters has not been examined in previous studies. The technology shifters estimated from optimal feed rations may differ by the growth period of each livestock production as well as under alternative market environments (e.g., alternative prices and availability conditions for feed ingredients).

The objectives of this study, therefore, are to (1) evaluate the livestock producers' potential benefits in feed cost reduction and changes in feed formulations by each livestock growth stage when newly modified soybeans are available in the market; and (2) test the robustness of potential benefits from modified soybeans under alternative price and availability conditions in the feed ingredient market.

DEVELOPMENT OF BIOTECH-SOYBEANS

Recent research attention to the development of biotech-soybeans has been centered in four broad areas: (1) genetic improvement of protein concentration and/

Table 1. Assumed Nutrient Composition of Regular 44% Soybean Meal[a] and Alternative Soybean Meals on As-fed Basis[b]

Nutrient	Soybean meal, 44%	HPSM[c]	HLSM[d]	HMSM[e]
M.E (Kcal/kg)	2,240	2,400	2,240	2,240
	(3,210)	(3,390)	(3,210)	(3,210)
Ca (%)	0.25	0.25	0.25	0.25
Available P (%)	0.23	0.23	0.23	0.23
Protein (%)	44.0	48.0	44.0	44.0
Methionine (%)	(0.68)	(0.72)	(0.68)	(0.94)
Methionine+Cystine (%)	1.40	1.44	1.40	1.72
	(1.15)	(1.18)	(1.15)	(1.34)
Lysine (%)	2.90	3.14	4.20	2.90
	(2.44)	(2.64)	(3.53)	(2.44)
Threonine (%)	1.70	1.94	1.70	1.70
	(1.31)	(1.49)	(1.31)	(1.31)
Tryptophan (%)	0.54	0.64	0.54	0.54
	(0.43)	(0.51)	(0.43)	(0.43)
Isoleucine (%)	2.05	2.15	2.05	2.05
	(1.70)	(1.76)	(1.70)	(1.70)
Valine (%)	2.16	2.34	2.16	2.16
	(1.75)	(1.89)	(1.75)	(1.75)

Notes: [a]NRC (1984, 1988).
[b]Numbers in parentheses are values of M.E and apparent ileal digestible amino acid for swine (Baker and Chung 1992; Heartland Lysine Inc. 1990).
[c]High-protein soybean meal.
[d]High-lysine soybean meal.
[e]High-methionine soybean meal.

or essential amino acid composition (e.g., Scott, Lago, and Nielsen, 1991; Shoemaker and Diers, 1991), (2) reduction or elimination of anti-nutritional factors (e.g., Bernard and Hymowitz, 1986; Orf, 1990), (3) genetic improvement of fatty acid composition of soybean oil (e.g., Fehr, Welke, Hammond, Duvick, and Cianzio, 1991; Wilcox, Cavins, and Nielsen, 1984) and (4) the development of disease resistant, herbicide resistant and insect resistant lines (e.g., Martin and Baumgardt, 1991).

Soybean modification scenarios in this study are related to the potential changes in protein and amino acid compositions of the soybeans. These modifications are economically relevant because soybean meal constitutes approximately 65% of the monetary value of soybeans, with approximately 95% of soybean meal used to supply protein and amino acids in livestock feed. Further, as noted earlier, previous studies reported that higher protein and better balanced amino acid soybeans for animal feed would likely result in great benefits in the livestock industry.

Previous research (Greiner, 1990) identified 30 potentially possible soybean modifications for various uses. We focus on three alternative modifications designed to increase protein and/or amino acid contents for animal feed. Nutritionally-altered soybean meals are considered to have been produced from these hypothetical soybean modifications. Nutrient composition of new alternative soybean meals, produced from these hypothetical soybean modifications, are compared with regular 44% protein soybean meal in Table 1.

HPSM high protein soybean meal has the greatest potential for technical feasibility while the rest of the alternatives still require significant research progress for their commercialization (Fehr, 1993). In general, standard soybeans containing 36% protein produce soybean meal with 44% protein content. The hypothetical new soybean meal with 48% protein content is expected to be obtained from newly modified soybeans with 40% protein content. This is not to be confused with currently existing dehulled soybean meal, which may contain 48% protein. Dehulled soybean meal is produced without being mixed with soybean hull and processing wastes. However, to increase profits, processors usually add soybean hulls and other processing wastes to soybean meal and, as a result, produce soybean meal with 44% protein. Hence, we assume that soybean meals in this study contain soybean hulls and processing wastes. As protein density is increased, amino acid contents are subsequently increased. As a result, HPSM would decrease soybean meal proportion in both swine and poultry diets.

HLSM is a high lysine soybean alternative expected to improve the feed efficiency for both hog and poultry producers. With a 1.3% increase of lysine content in meal protein, dietary targets would be accomplished in a ration with a lower proportion of high-lysine soybean meal, a higher proportion of feed grains, and no supplemental synthetic L-lysine.

HMSM is a high-methionine soybean meal. With a 0.32% increase of methionine content in meal protein, meal demand would increase mainly from poultry producers who would be able to eliminate supplemental synthetic DL-methionine from existing rations. Since HMSM is expected to increase primarily feed efficiency for poultry producers, a new high-methionine soybean meal is incorporated into poultry rations only.

METHODOLOGY

The major impact of modified soybeans with higher protein or amino acid content is expected on poultry and swine producers. To estimate the economic potential of these modified soybeans, least-cost formulations of several diets are made for each poultry and swine growth stage with specific nutrient constraints, allowing only a few ingredients including corn, soybean meal, and crystalline amino acids. Then each alternative soybean meal is introduced into the diet, and the formulation is solved again. The formulation results with and without new high quality soybean meal are compared to determine the relative economic value of alternative soybean meals and the change in feed formulations.

The optimal diet model representing livestock producers' feed cost minimizing behavior can be described as a linear programming problem. The problem is to choose non–negative values of feed input variables to minimize feed cost subject to a set of nutrient constraints. Formally this is represented by:

$$\min_{x} \{C(x) = wx: Ax \geq a, x \geq 0\}, \quad (1)$$

where $x \in R^n_+$, $w \in R^n_+$, and $a \in P^m_+$; n is the number of ingredients available; m is the number of nutrients considered; and A is an m x n matrix of nutrient coefficients. Here, x is a vector of feed inputs and a is a vector of nutrient constraints. A typical element in the matrix A, a_{ij}, is the amount of the i-th nutrient in the j-th ingredient. The solution process of this problem involves finding a set of points (an optimal feed input set) on the contour of the objective function lying closest along the preference direction but within the convex input opportunity set. This is the method routinely used for least-cost formulation of diets in the livestock industry. Soybean biotechnology is expected to change one or more elements of matrix A and expand the feed ingredient opportunity set. From the geometry, this change would allow livestock producers to choose better combinations of feed ingredients to reduce their feed cost.

The prices of new soybean meals are considered to be the same as the price of conventional soybean meal because no price for the new alternative soybean meals is available in the market. However, this assumption may not be realistic because if the quality of the product is improved, it is reasonable to expect that the new products command premium prices. Further, if these new soybean meals do not receive premium price from livestock producers, there will be no incentive for soybean producers and processors to introduce these new products in the market.

To satisfy this concern, we also evaluate imputed prices (the sum of the products of the levels of nutrients and corresponding shadow prices) of the new soybean meals in diets. The estimated imputed prices are considered as the maximum amount of premium prices that livestock producers can pay for each alternative soybean meal. If no extra benefit is taken by livestock producers, the estimated prices are premium prices in the market. However, in reality, the premium prices would be determined somewhere between price of conventional soybean meal and the imputed prices of the new soybean meals, depending upon the efficiency of price transmission in the market system. As the premium prices approach the imputed prices, cost benefits for the livestock producers are expected to decrease. Therefore, feed-cost savings estimated by comparing formulas with and without new high-quality soybean meals given same ingredient prices are the maximum estimates of cost savings for the livestock producers.

A conceptual basis of the shadow price can be found in the dual to the problem (1):

$$\max_{q} \{a^T q: A^T q \leq w^T, q \geq 0], \quad (2)$$

where $q \in R^m$ is a column vector. The interpretation of the dual variable q can be derived directly from the duality theorem. One of the implications of the duality theorem is that the optimal values of the primal and dual problems equal each other (Hazell and Norton, 1986):

$$wx^* = a^T q^* \tag{3}$$

Differentiating (3) with respect to vector a gives:

$$\frac{\partial wx^*}{\partial a} = \frac{\partial a^T q^*}{\partial a} = q^* \tag{4}$$

Equation (4) states that the effect of one unit change in a nutrient requirement in vector a on the minimum feed cost (wx^*) is given by the optimal value of the corresponding dual variable in vector q^*. Here, the solution vector q^* of the dual problem provides imputed prices of nutrients specified in the nutrient requirement vector a and are called shadow prices.

To estimate cost savings, imputed prices, and dietary changes in livestock production, optimal diet problems of each growth stage, stated in equation (1), are solved by choosing quantities of each feed ingredient. Estimates of cost savings from each growth stage are computed by comparing diet costs with and without alternative soybean meals. For the comparison of potential feed cost savings for each livestock production, weighted average is also computed for each livestock group using feed consumption weight and daily feed intake multiplied by days on feed for each feeding period (National Research Council 1984; 1988). Then, the robustness of the solutions is tested by changing price vectors of key ingredients and by adding more protein sources to the problems. The linear programming models are developed and solved using LP88 software (LP88, 1987).

DATA SOURCES

Requirement estimates of the National Research Council (NRC) are taken as minimum nutrient level constraints (NRC, 1984; 1988). Unlike Greiner (1990), this study does not specify protein requirements, but instead requires minimum levels of six essential amino acids because practical diets for poultry and swine have been widely formulated on the basis of meeting needs for essential amino acids. Amino acid requirements of swine diets are determined by the ideal protein ratios of Baker and Chung (1992) and are stated on an apparent ileal digestible amino acid basis.

Ingredients considered for the base models are corn, soybean meal, vegetable and animal fat, L-lysine, DL-methionine, L-threonine, L-tryptophan, calcium carbonate, dicalcium phosphate, and vitamin and mineral mix. The historical feed

Table 2. Average Feed Ingredient Prices During 1990–1992, Chicago or Minneapolis/St. Paul[a]

Ingredients	*Price ($/ton)*
Corn	87.60
Soybean meal (44%)	170.40
Vegetable & animal fat	251.40
L-Lysine	2,360
DL-Methionine	2,960
L-Threonine	6,000
L-Tryptophan	12,000
Calcium carbonate	40.00
Calcium phosphate, dibasic	230.00
Vitamin & mineral mix	1,100

Notes: [a]*Feedstuffs* and personal conversations with feed ingredient distributors and synthetic amino acid producers.

ingredient prices are taken from *Feedstuffs* for the input price vector of optimal diet problems. The mean of the first week prices at Chicago for each month between January 1990 and December 1992 is used as the price of each input. Because Chicago base price was not available for vegetable and animal fat, price at Minneapolis/St. Paul is used for this ingredient. Prices of minor ingredients such as L-lysine, DL-methionine, L-threonine, L-tryptophan, and vitamin and mineral mix are taken from personal conversations with several feed input distributors and synthetic amino acid producers. Prices of ingredients used in the optimal diet models are listed in Table 2. The nutrient contents of feed ingredients used in the feed mix are based on NRC (1984) for poultry and on NRC (1988) and Heartland Lysine Inc. (1990) for swine.

RESULTS: COST SAVINGS AND SENSITIVITY ANALYSIS

In general, turkey and broiler growers would have larger benefits than layer and swine growers, and cost savings were significantly larger in starter diets than in either grower or finisher diets (Table 3). For instance, when HPSM was used in starter diets, the feed costs were decreased by 5.4, 4.4, 1.4, and 4.1% in turkey, broiler, egg, and pork production, respectively, but the savings were reduced to 2.9, 3.4, 0.9, and 1.0%, respectively, in finisher diets. Similar results were reported when HMSM was used for turkey and broiler production. When HLSM is applied, turkey growers would have the biggest cost saving, $5.63 (4.3%) per ton, from the grower diet (8-12 weeks), while broiler growers would have the same level of benefits across growth stage. Layer diets showed minimal responses with a slightly different direction. Overall results indicate that previous research (Greiner 1990) might overestimate the potential benefits of alternative soybean meals by generalizing the benefits from starters to the whole growth period.

Table 3. Livestock Producers' Cost Savings from Alternative Soybean Meals

			Cost Savings($/ton)[b]		
Animal	*Stage*	*Base Model[a] Feed Cost ($/ton)*	*HPSM*	*HLSM*	*HMSM*
Turkeys	0-4 weeks	148.16	7.97	2.89	4.08
	4-8 weeks	142.48	7.15	4.05	3.15
	8-12 weeks	132.32	5.50	5.63	2.83
	12-16 weeks	122.78	4.45	1.39	1.94
	16-20 weeks	115.21	3.44	0.07	0.74
	Weighted average[c]	124.99	4.72	2.11	1.89
Broilers	0-3 weeks	148.11	6.44	0.48	3.30
	3-6 weeks	131.22	5.04	0.48	2.47
	6-8 weeks	122.21	4.11	0.48	1.75
	Weighted average[c]	129.77	4.84	0.48	2.28
Layers	0-6 weeks	115.63	1.63	0	0.66
	6-14 weeks	108.57	1.16	0	0
	14-20 weeks	99.97	0.46	0.48	0.20
	Laying	105.84	0.99	1.03	1.23
	Weighted average[c]	105.77	0.97	0.89	1.04
Swine	10-20 kg	127.95	5.28	0	NT[d]
	20-50 kg	118.98	3.34	3.97	NT[d]
	50-80 kg	109.62	1.65	2.42	NT[d]
	80-110 kg	104.90	1.03	1.30	NT[d]
	Weighted average[c]	111.19	2.05	2.19	NT[d]

Notes: [a]Feed cost without alternative soybean meals.
[b]Cost savings with alternative soybean meals.
[c]Weighted for feed consumption of each feeding period.
[d]Not tested.

The weighted averages of cost savings from HPSM and HMSM showed larger benefits in turkey and broiler production than in egg and pork production. HLSM produced better results for turkey and pig growers than for broiler and layer growers.

Imputed prices reported in Table 4 are user values evaluated by end-users (here livestock producers) for the alternative soybean meals given price and nutrient vectors of ingredients. As expected, imputed prices of HPSM and HMSM were higher in turkey and broiler diets than in layer and swine diets, while imputed prices of HLSM were higher in turkey and swine diets. It is also noted that the imputed prices are generally higher in starter diets than grower or finisher diets. HPSM showed the highest price in broiler diets for 3 to 6 weeks and 6 to 8 weeks at $189.38 (approximately 111% of conventional soybean meal price) while almost no premium value was found for HLSM in pig starter diet. The highest imputed prices for HLSM and HMSM were $185.52 and $180.32 in pig grower (20 to 50 kg) diet and in broiler starter diet, respectively, which were approximately 108% and 106% of conventional soybean meal prices. The results indicate that the new soybean meals are not economically attractive when premium prices over regular soybean meal exceed 11% for HPSM, 8% for HLSM, and 6% for

Table 4. Imputed Prices of Alternative Soybean Meals in Poultry and Swine Diets

		Imputed Price ($/ton)[a]		
Animal	*Stage*	*HPSM*	*HLSM*	*HMSM*
Turkeys	0-4 weeks	188.88	177.66	180.16
	4-8 weeks	188.92	180.10	178.22
	8-12 weeks	188.92	183.40	177.52
	12-16 weeks	188.88	174.52	175.68
	16-20 weeks	188.88	171.74	173.16
Broilers	0-3 weeks	188.92	172.86	180.32
	3-6 weeks	189.38	172.86	178.04
	6-8 weeks	189.38	172.86	176.16
Layers	0-6 weeks	177.50	171.10	173.10
	6-14 weeks	177.88	170.56	171.80
	14-20 weeks	177.56	173.52	172.42
	Laying	177.56	175.74	176.54
Swine	10-20 kg	187.36	170.90	NT
	20-50 kg	184.58	185.52	NT
	50-80 kg	182.62	183.60	NT
	80-110 kg	176.86	181.60	NT

Notes: [a]Sum of the products of the levels of nutrients and corresponding shadow prices.

HMSM. In other words, any price premium offered by livestock producers is not likely to exceed 11%.

Another important question from livestock producers may be: "How will new soybean meals change the ingredient compositions of livestock diets?" For brevity, we reported change in major ingredient compositions only in starter and finisher diets (Table 5). High-protein soybean meal, HPSM, reduced soybean meal use ranging from 1.3% (broiler 6 to 8 weeks) to 3.7% (broiler 0 to 3 weeks) while increasing corn proportion ranged from 0.1% (broiler 6 to 8 weeks) to 5.9% (broiler 0 to 3 weeks). Differences between decreased soybean meal and increased corn usages were primarily attributed to the change in vegetable and animal fat usages. Under the specified assumptions on ingredient price, nutrient compositions, and nutrient requirements in diets, HLSM replaced synthetic lysine completely in both turkey starter and hog finisher diets. With HMSM, synthetic methionine was eliminated from most poultry diets.

Finally, the robustness of the results was tested under different market environments. We considered different price scenarios for key ingredients as well as different types of protein sources available. High and low price levels for each ingredient were taken as one positive and one negative standard deviation from the ingredient prices of the base model (listed in Table 2), respectively. Very high price levels were also included to consider such exceptionally high price markets as those in 1995 and 1996. These levels are mean prices of each ingredient between August 1995 and September 1996. Optimal diet models were solved for each growth period with each price scenario. Results were weighted for feed consump-

Table 5. Change in Optimal Level of Main Ingredients in Poultry and Swine Feeds

Animal/stage	*Condition*	*Corn*	*Regular SBM (44%)*	*New SBM*	*L-Lysine*	*DL-Methionine*
		%	%	%	%	%
Turkeys/	with regular SBM	45.29	47.75	0	0.12	0.25
0-4 weeks	plus HPSM	49.09	0	46.25	0.02	0.22
	plus HLSM	45.56	0	47.71	0	0.25
	plus HMSM	45.60	0	47.70	0.12	0.07
16-20 weeks	with regular SBM	74.64	20.56	0	0	0.02
	plus HPSM	77.72	0	18.64	0	0.02
	plus HLSM	74.64	0	20.56	0	0.02
	plus HMSM	74.69	0	20.55	0	0
Broilers	with regular SBM	49.43	38.44	0	0	0.30
0-3 weeks	plus HPSM	55.29	0	34.77	0	0.27
	plus HLSM	54.31	0	34.43	0	0.34
	plus HMSM	49.68	0	38.39	0	0.14
6-8 weeks	with regular SBM	70.96	22.70	0	0	0.06
	plus HPSM	71.10	0	21.37	0	0.02
	plus HLSM	76.52	0	18.13	0	0.10
	plus HMSM	71.08	0	22.69	0	0
Layers	with regular SBM	71.84	25.00	0	0	0.02
0-6 weeks	plus HPSM	73.91	0	22.90	0	0.02
	plus HLSM	71.84	0	25.00	0	0.02
	plus HMSM	71.86	0	25.00	0	0
Laying	with regular SBM	74.90	15.10	0	0	0.10
	plus HPSM	76.16	0	13.81	0	0.10
	plus HLSM	76.86	0	13.08	0	0.12
	plus HMSM	74.94	0	15.09	0	0.02
Swine	with regular SBM	59.73	36.33	0	0	0
10-20 kg	plus HPSM	63.42	0	33.31	0	0
	plus HLSM	61.34	0	34.73	0	0
80-110 kg	with regular SBM	84.01	13.49	0	0.02	0
	plus HPSM	86.29	0	11.14	0.05	0
	plus HLSM	78.82	0	18.74	0	0

tion of each feeding period for each livestock species (Table 6). Comparing price scenarios, all alternative soybean meals resulted in the largest benefit under the scenario of high soybean meal and low corn prices. However, the change in cost savings due to different price scenarios was within a modest range and orders in cost saving benefits from each alternative generally remained unchanged.

Cost saving benefits were also compared while two additional high-protein ingredients were permitted in feed diets (Table 7). They were meat and bone meal and canola meal. Prices of these ingredients used for the analysis were $212.20/ton for meat and bone meal, and $117.60/ton for canola meal, the average Chicago base prices between January 1990 and December 1992. No other ingredient price parameters were allowed to change from the base model ingredient prices. The nutrient contents of meat and bone meal and canola meal were based on NRC (1984; 1988).

Table 6. Sensitivity Analysis Results: Cost Savings when Ingredient Price Parameters Change while No Alternative Protein Sources are Available

	Price ($/ton)[a]		*Base Model*[b]	*Cost Savings ($/ton)*[c]		
Animal	*SBM*	*Corn*	*Feed Cost ($/ton)*	*HPSM*	*HLSM*	*HMSM*
Turkeys	Low	Low	117.87	4.83	1.90	1.96
	Low	High	126.74	4.58	1.80	1.96
	High	Low	123.23	5.32	2.00	1.97
	High	High	132.09	4.74	1.89	1.94
	Very high	Very high	167.66	4.17	1.76	1.90
Broilers	Low	Low	122.81	4.91	0.43	2.29
	Low	High	131.29	4.50	0.01	2.24
	High	Low	127.98	5.23	1.28	2.30
	High	High	136.60	4.78	0.55	2.28
	Very high	Very high	170.98	4.15	0.01	2.22
Layers	Low	Low	99.18	0.94	0.85	1.04
	Low	High	109.42	0.77	0.74	1.04
	High	Low	101.97	1.18	1.19	1.09
	High	High	112.21	1.01	0.94	1.04
	Very high	Very high	147.41	0.92	0.83	1.03
Swine	Low	Low	104.04	1.98	2.12	NT
	Low	High	114.34	1.69	1.81	NT
	High	Low	107.89	2.48	2.64	NT
	High	High	118.19	2.12	2.27	NT
	Very high	Very high	155.38	1.92	2.05	NT

Notes: [a] *Feedstuffs*, January/1990-December/1992 and August/1995-September/1996. Low, high, and very high prices for soybean meal are $161.0, $179.8, and $212.0, respectively, and low, high, and very high prices for corn are $80.8, $94.2, and $134.0, respectively.
[b]Feed cost without alternative soybean meals.
[c] Cost savings with alternative soybean meals

Proportions of these two additional protein sources in the feed mix were limited for both poultry and swine diets. For poultry diets, meat and bone meal was permitted at levels up to 5% in turkey and layer diets, and to 3% in broiler diets for all growth periods. Canola meal was permitted up to 10% in broiler and layer diets and up to 20% in turkey diets for all growth periods. For pig feeds, the limitation was imposed only to starter and grower diets. The maximum uses of meat and bone meal and canola meal were 5% and 10% for 10 to 20 kg, and 20 to 50 kg diets, respectively.

As shown in Table 7, the cost saving benefits were significantly affected when additional protein sources were available for diet formulations. Cost savings from all poultry diets decreased by 60% while cost savings from pig diets increased by 40%. One of the logical explanations for this result might be that the relative values of two additional protein sources to alternative soybean meals were higher in poultry feeds than in swine feeds under current price, nutrient composition, and diet standard assumptions. In other words, the modified soybean meals were more cost effective in swine diets than in poultry diets when additional protein sources were available. For all poultry diets with and without new soybean meals, the usage of meat and bone meal, and canola meal hit the maximum limitations set for each diet. This indicates that the additional protein sources were still strongly demanded in

Table 7. Sensitivity Analysis Results: Cost Savings when Alternative Protein Sources are Available while No Ingredient Price Parameters Change

Animal	*Base Model Feed Cost ($/ton)*[a]	*Cost Savings ($/ton)*[b]		
		HPSM	*HLSM*	*HMSM*
Turkeys	120.67	2.08	0.83	0.79
Broilers	125.23	2.82	0.35	1.40
Layers	102.57	0.73	0.24	0.37
Swine	110.74	2.84	3.02	NT

Notes: [a]Base model feed cost with two additional protein sources but without alternative soybean meals.
[b]Cost savings with alternative soybean meals.

poultry diets although new high quality soybean meals were available. However, for swine production, meat and bone meal was not used in most diets either with or without alternative soybean meals. Canola meal was used in the swine diets at the maximum limit before alternative soybean meals were available, but its usage was sharply decreased after alternative soybean meals were introduced.

CONCLUSIONS

Hypothetical biotech soybeans simulated in this study have superior protein and amino acid levels compared to traditional soybeans, and are projected to be used primarily for livestock production. Overall, livestock producers can expect to reduce feed costs by 0 to 5% by using new soybean meals, while turkey and broiler producers would benefit more than egg and swine producers. Of the three alternatives, HPSM showed the largest potential benefits in turkey and broiler production and approximately the same level of benefits as others in egg and swine production. Generally, cost savings were significantly larger in starter diets than in either grower or finisher diets. For instance, cost benefits from HPSM in pig-starter diet was four times larger than in pig-finisher diet. Accordingly, previous research such as Greiner (1990) might have overestimated the potential benefits of alternative soybeans in livestock production by generalizing the benefits from starters to the whole growth period.

The various price scenarios examined had little effect on predicted savings from the use of alternative soybean meals, and orders in cost benefits remained unchanged. However, changes in cost savings due to the higher availability of protein sources were relatively large. In markets where more high-protein ingredients were available, poultry producers tended to benefit less and swine producers benefitted more from altered soybean meals, while profitability orders for each livestock group were unchanged.

The findings showed economic advantages of altered soybean meals were highly sensitive to the growth period of each livestock production and the availability of alternative protein sources, but less sensitive to changes in ingredient prices. These findings indicate that economic benefits of modified soybeans in the livestock industry should not be casually evaluated in one representative formulation for each livestock production and in a simple corn-soybean meal diet. Rather, the findings suggest the economic evaluation of soybean biotechnology in the livestock industry should be carefully conducted in feed formulations of each livestock growth period with consideration of various conditions of feed ingredient availability.

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