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How Does Cottonseed Meal Compare as an Alternative Protein Source to Soybean Meal in Poultry Production ?

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HOW DOES COTTONSEED MEAL COMPARE AS AN ALTERNATIVE PROTEIN SOURCE TO SOYBEAN MEAL IN POULTRY PRODUCTION ?

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ABSTRACT

Profitability of substituting cottonseed meal (CSM) for soybean meal (SBM) in broiler feed is evaluated using a model that optimizes broiler production under changing market conditions. While CSM-fed broilers may earn higher profits for whole carcass, SBM-fed broilers are generally more profitable. Optimal protein levels exceed currently recommended levels.

Key words: *Soybean meal, cottonseed meal, maximum profit, protein levels.*

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INTRODUCTION

Because of its high protein level concentration, cottonseed meal may be used as a protein source for poultry production. However, can cottonseed meal replace other protein sources, mainly soybean meal, currently used in the United States, efficiently? In this study, we analyze the use of cottonseed meal in poultry production and compare it to the use of soybean meal from the viewpoint of an integrated poultry producer that faces different prices of inputs (soybean meal vs cottonseed meal) and different prices of outputs (live, carcass or cut-up chickens). The emphasis of this study is not only on the technical efficiency obtained by feeding either soybean meal or cottonseed meal, which is important but not the essence of making profits in poultry production, but also on the economic efficiency obtained from the processing and selling of poultry fed either of the two protein sources.

Cottonseed meal is the second most valuable product (cottonseed oil is the most valuable product) derived from the cottonseed crush. Cottonseed yields 900 pounds (45%) of cottonseed meal for each ton that is crushed (National Cottonseed Products Association, NCPA, 1999), as shown in Figure 1. Cottonseed meal is a high protein level feed ingredient whose first limiting amino acid is lysine (Grau 1946, and Anderson and Warnick, 1966). The use of cottonseed meal in the United States is concentrated in feed for livestock and is usually sold between 40% and 42% protein level (NCPA, 1999). The main obstacle in managing cottonseed meal for poultry and livestock rations is the presence of gossypol due to current processing techniques that cause lysine deficiency (Fisher and Quisenberry, 1971). In Canada, cottonseed meal is used as a protein source for broiler chickens in addition to soybean meal and other protein sources. Canadian analysis of cottonseed meal in poultry diets shows that when supplemented with lysine, cottonseed meal reaches productivity levels comparable to soybean meal (Campbell, 1988).

When searching for alternative protein sources for poultry or livestock feed, in addition to the feeding response, quality and safety aspects, integrators are also concerned about the availability of the alternative protein source(s), storage and marketing of these alternatives. Among all protein sources, excluding soybean meal, cottonseed meal is the most traded and it is priced in at least seven different major markets in the United States (Feedstuffs, 2000).

Profitable use of cottonseed meal requires that the price of cottonseed meal must be lower than the price of soybean meal. Not only that, cottonseed meal fed chickens must be as productive as soybean meal fed chickens, or if not as productive, the price for cottonseed meal must be such it compensates for the lower productivity of the cottonseed meal fed chickens. The price difference of protein sources is important because protein sources in the diets account for approximately 30% of the total diet for high protein level feeds. Historical data on prices show that soybean meal price has always been higher than the price of cottonseed meal for the market based in Atlanta, GA (Feedstuffs, 2000).

The profit-maximizing analysis for cottonseed and soybean meal fed poultry presented in this study is composed of two sections. First, estimated response functions are computed to determine the production functions to be used in the profit maximization model. Second, results obtained from the optimization scenarios are used for profitability analysis of the competing protein sources where output prices vary in the model.

RELATED LITERATURE

This section presents technical studies that have compared the use of cottonseed meal to soybean meal in poultry diets. Summaries of previous studies that use profit maximization within a mathematical programming context in poultry production and/or feed formulation are also presented.

Studies on Cottonseed Meal as a Protein Source for Poultry

An extensive production analysis has been applied to finding technically efficient protein substitutes for soybean meal in poultry production. Peanut, canola, and sunflower meal are some of the many protein meals cited in previous studies, but according to authors of these studies, these protein sources do not completely replace soybean meal. That is, they do not demonstrate greater weight gains, less feed consumed, or better feed conversion than soybean meal feeds when fed to broilers alone. The interest expressed on cottonseed meal is greater than others, because, as already mentioned, cottonseed meal availability decreases shortage risks assumed when one uses an alternative protein source and ensures a higher quality level than the other sources.

Watkins et al. (1993) provide a description of the history of using cottonseed meal in poultry and some discussion on the recent use of cottonseed meal in poultry diets. In their first study, they analyze the effect of levels of cottonseed meal utilization on poultry diets and lysine supplementation. They estimate production functions for the effects of cottonseed meal levels on feed intake and on feed utilization and conclude that there does not appear to be any significant relationship between dietary lysine supplementation and response to cottonseed meal.

Watkins et al. (1994) analyze the influence of assigned metabolizable energy values and supplementation with essential amino acids on the performance of cottonseed meal fed chickens. Their studies compare treatments where soybean meal is used solely and treatments where levels of cottonseed meal are added to the diets. Their analysis show that there is no significant difference in body weight for any of the treatments, but that feed consumption is higher for diets with cottonseed meal added. The use of two protein sources in the same diet makes it difficult to distinguish the effects of each source in the body weight and feed consumption responses of the chickens.

Watkins and Waldroup (1995) study the use of higher concentrated protein on cottonseed meal (44.96%) in poultry diets. They compare soybean meal fed broilers with diets that contain soybean meal and levels ranging from 10% to 30% cottonseed meal as percentages of the diet. They add the necessary amino acid supplements to these cottonseed meal diets and compare them to the soybean meal diet. Their results first show that cottonseed meal is more suitable for finisher diets (21-42 days) and that 30% cottonseed meal levels in the diet result in birds that weigh less and eat less than in the other treatments.

These studies show promising results for the use of cottonseed meal as a complement for soybean meal in poultry diets, if not as a substitute. This may be due to the fact that it is believed that higher levels of cottonseed meal may not be as efficient as levels used in past studies. Our study uses data obtained by an experiment conducted at the University of Georgia[1], which uses full substitution of protein sources; i.e., experiments are conducted with diets that contain either soybean meal or cottonseed meal for the collection of information on live body weight, feed consumption and weight of processed parts. This data set, which contains productivity information on each source (soybean meal vs cottonseed meal) is used to estimate the production functions that will be used in the profit maximization model of this study.

Profit Maximization and Cost Minimizations Models

[1] Feed composition and feeding level experiment was conducted by Dr. Gene M. Pesti, Department of Poultry Science, University of Georgia. The experiment consisted of using four different levels of protein (17%, 20%, 23%, and 26%) and two different sources of protein (soybean meal vs cottonseed meal) to feed broiler chickens until 42 days and collecting body weight, feed consumed and weight of processed parts. For more detailed information, contact the authors.

Starting in the 1950's with the wide-spread adoption of mathematical programming, interest in feed formulation was renewed. For decades, the major objective to be attained in optimal broiler production was to minimize the cost of feed, and little consideration was allocated to other determinants of maximum profit. Least cost rations minimize the cost of diets, given a certain set of ingredients and their nutritional content. An important assumption of least cost formulated diets is that every unit of a least cost formulated ration has the same productivity regardless of ingredient sources (Allison and Baird, 1974).

The adoption of simple cost minimization does not account for differentials in productivity among input sources; e.g., broiler performances in experimental trials of those fed peanut meal protein vs. those fed soybean meal protein have been shown to differ significantly (Costa et al., 1998).

On the other hand, the adoption of profit maximization techniques later in the 1990's has taken into consideration the productivity aspect of economically efficient broiler production. Few models have been developed thus far, and they differ in their approaches to the problem.

Gonzalez-Alcorta et al. (1994) developed a profit maximization model that uses nonlinear programming and separable linear programming to determine the precise energy and protein levels in the feed that maximize profit. Their model is distinguished by the assumption that body weight is not fixed at a predetermined level. Feed cost is not determined by least cost feed formulation. Rather, feed cost is determined as a variable of the profit maximization model in a way similar to that described in Pesti et al. (1986). They conclude that the mathematical programming functions applied in their model show that setting energy and protein levels that vary with output and input prices can raise profit compared to fixed diet levels of energy and protein based on previous nutritional guidelines.

Costa et al. (1998) developed a 2-step profit maximization model that minimizes feed cost and maximizes profit in broiler production. The model shows the optimum average feed consumed, feed cost, live and processed body weight of chickens, as well as the optimal length of time that the broilers must stay in the house and other factors, for given temperature, size of the house, cost of inputs and outputs and for certain pre-determined protein level, source, and processing decisions. They conclude that peanut meal can be more profitable than soybean meal for growing birds to be processed and sold as whole carcasses.

The analysis conducted in our study differs from Costa et al. (1998) by developing a model that allows for a single procedure that will select the optimum protein level and formulated ration to be fed to the chickens for either protein source. This model generates processing alternatives for selling whole carcass and cut-up parts, but it also has an option for selling live broilers (mainly for international markets). It also generates results for male and female fed broilers and generates results for step-pricing analysis of feedstuffs and/or inputs. As for the main objective of this study, analysis for step-pricing and use of female chickens will not be necessary. Further studies will include such analysis.

MODEL DESCRIPTION AND ESTIMATION OF PRODUCTION FUNCTIONS

$$Max \ Đ = \{(EFP_B * BW) - [(P_F + DEL) * F_C] * I\} \ / \ t \qquad \textbf{(1)}$$

A brief description of the model follows[2]. The objective function to be optimized is:

Subject to:

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[2] The objective of this paper is not to discuss the description and functionality of the proposed model. For a more detailed description, contact the authors.

$$P_F = \sum_{i=1}^{n} P_i * X_i \quad \textbf{(2)}$$

$$BW = a_1 + b_1 * F_C + b_2 * F_C^2 + b_3 * PR + b_4 * PR^2 + b_5 * FE \quad \textbf{(3)}$$

$$F_C = a_2 + b_5 * t + b_6 * t^2 + b_7 * PR + b_8 * PR^2 + b_9 * FE \quad \textbf{(4)}$$

$$w_{WC} = a_3 + b_{10} * BW + b_{11} * PR + b_{12} * PR^2 + b_{13} * FE \quad \textbf{(5)}$$

$$w_{FP} = a_4 + b_{14} * BW + b_{15} * PR + b_{16} * PR^2 + b_{17} * FE \quad \textbf{(6)}$$

$$w_{BR} = a_5 + b_{18} * BW + b_{19} * PR + b_{20} * PR^2 + b_{21} * FE \quad \textbf{(7)}$$

$$w_{TE} = a_6 + b_{22} * BW + b_{23} * PR + b_{24} * PR^2 + b_{25} * FE \quad \textbf{(8)}$$

$$w_{LQ} = a_7 + b_{26} * BW + b_{27} * PR + b_{28} * PR^2 + b_{29} * FE \quad \textbf{(9)}$$

$$w_{WI} = a_8 + b_{30} * BW + b_{31} * PR + b_{32} * PR^2 + b_{33} * FE \quad \textbf{(10)}$$

$$w_{RC} = a_9 + b_{34} * BW + b_{35} * PR + b_{36} * PR^2 + b_{37} * FE \quad \textbf{(11)}$$

The objective function, maximum profit per bird per day (Π), is defined as a function of equivalent farm price (EFP_B), live body weight (*BW*), feed cost (P_F), feed delivery cost (*DEL*), feed consumed (F_C), interest cost (*I*), and number of broiler feeding (finishing) days (*t*), equation 1. Due to space limitations, the constraint set includes a number of equations that are not mentioned in this article. However, the most relevant equations that allow for a direct comparison between the two sources of feed protein are described next. The least cost feed function minimizes the cost of feed for pre-determined ingredients (X_i) and their prices (P_i) and is determined by optimization process (2). Live chicken body weight (*BW*) is determined by feed consumed (F_C), square of feed consumed, protein level (*PR*) and an intercept shifter for female chickens (*FE*, 3). Coefficients a_1 and b_1 through b_5 are determined by regression analysis on experimental data, and their values depend on whether soybean meal (SBM) or cottonseed meal

(CSM) is chosen as the protein source. Further, coefficients in equations 4 - 11 are also estimated separately for SBM and for CSM . Coefficient a_1 is modified by the intercept shifter (*FE*), representing the estimation of body weight for female birds. Feed consumed is determined by time, protein level (*PR*), and the intercept shifter for female chickens (4). Coefficients a_2 and b_5 - b_9 are determined by ordinary least squares (OLS) regression analysis on experimental data, and their values also depend on whether SBM or CSM is chosen as protein source. Coefficient a_2 is modified by the intercept shifter adjusting for the use of female birds in the production process.

Equations 5-11 are estimated as processed weight, w_l, of each part *l* derived from a live bird (*l* = *WC* for whole carcass, *BR* for breast weight, *TE* for tender, *LQ* for leg quarter, *WI* for wings, *FP* for fat pad, and *RC* for rest of chicken). The sum of all processed parts must be equal to the live weight of the bird (plus offal and giblets). Each equation is estimated as a function of live bird weight, protein level and gender of birds. The coefficients that appear in equations 5-11 are also to be estimated by OLS on experimental data, and their values also depend on whether SBM or CSM is chosen as protein source, with coefficients a_3 and a_4 modified by the use of female chickens in the process. Likewise, coefficients a_3 - a_9 are modified by the use of female chickens in the process.

ESTIMATED PRODUCTION FUNCTIONS AND PRICES DATA

Production equations 3 - 11 are estimated by OLS (Tables 1 - 3). Table 1 shows the estimated coefficients of equations 3 - 5 for both CSM and SBM fed chickens. Live bird weight (*BW*) increases at a decreasing rate with respect to feed consumed (F_C) and protein level (*PR*), while feed consumed decreases at an increasing rate with respect to time (*t*) and increases at a decreasing rate with respect to protein level (*PR*). Weight of whole carcass (W_{WC}) increases at a decreasing rate with respect to protein level (*PR*).

Estimated coefficients of equations 6 - 11, production responses of broiler parts, are shown in Table 2 for CSM-fed chickens. Weights of breast, tender, leg quarters, and wings (W_{BR}, W_{TE}, W_{LQ}, and W_{WI}, respectively) increase at increasing rates with respect to *PR*. Weights of fat pad and rest of chicken (W_{FP} and W_{RC}, respectively) decrease at increasing rates with respect to *PR*. Table 3 shows the estimated coefficients of production responses in equations 6 - 11 for SBM-fed chickens. Weights of breast, tender, leg quarters, wings, and rest of chicken (W_{BR}, W_{TE}, W_{LQ}, W_{WI}, and W_{RC}, respectively) increase at increasing rates with respect to *PR*. Weight of fat pad (W_{FP}) decreases at an increasing rate with respect to *PR*. These results concur with those of Pesti and Smith (1984) that show that production responses of broilers to dietary energy and protein levels show diminishing marginal returns.

Prices are collected for the profit maximization analysis and are reported in Tables 4 and 5. Table 4 includes prices of ingredients available for the ration formulation, including major feedstuffs and synthetic amino acids that supplement the deficiencies of major sources such as CSM. Table 5 includes prices received in Georgia (or the Southeast) for the outputs considered in the analysis as well as other costs considered in the analysis and their sources. Other inputs to the model include average temperature of the house (set equal to 60 degrees Fahrenheit), and size of the house (set equal to 20,000 square feet).

MODEL ITERATIONS AND PRICE ANALYSIS

This model estimates the profitability of six different scenarios where broilers are produced and sold using either soybean meal or cottonseed meal as the protein source. Broilers are sold either after being processed into whole carcasses or cut-up parts, or as live birds (international markets). Thus, in a total of six different scenarios are analyzed in this study. Comparisons are made directly between CSM vs SBM results for each selling alternative. All formulated rations presented in Table 6 meet all nutrient requirements from the National Research Council (NRC, 1994) for the nutrient requirements of poultry production.

Selling Broilers in the Whole Carcass Market

The first analysis compares selling broilers that are processed into whole carcass. The feed formulated for CSM has less corn and more poultry fat than the SBM ration, but more CSM is used than for SBM rations in its composition. Both feed scenarios demonstrate optimal protein levels that are higher than the levels fed in the industry (Table 6). CSM feed costs more than the SBM feed, but the profit generated by giving it to the broilers is higher than the profit generated by SBM-fed broilers (Table 7). This represents the only scenario at current prices where CSM is more profitable than SBM.

Selling Broilers in the Live Market

Since there is no quote available for live broilers, a price is assumed for comparison of the two sources since, and the same price is applied in both models. The formulated diets suggested by the model have protein levels that are higher than current industry standards. The CSM and poultry fat in the diet are again very high (CSM and poultry fat are responsible for 35.68% and 10.84% of the total diet, respectively). SBM in this model is fed for a longer period, but its feed cost is lower than the CSM ration and generates a higher profit.

Selling Broilers in the Cut-up Parts Market

Selling broilers processed into cut-up parts generates the highest profits overall. Even though this study differs significantly to the study conducted by Costa et al. (1998), the results obtained in that study are similar to these regarding the conclusion that feeding SBM to broilers to be sold at the cut-up parts market results in the most profitable scenario. Results in this study show that the protein level remains high relative to current industry practice, and the use of SBM in the diet is at its highest level of the three diets. The feeding process is also the longest for this alternative, and feed cost is the highest of all SBM scenarios.

CONCLUSIONS

Results obtained from profit maximization programming models show that soybean meal is generally more efficient than cottonseed meal and, at the set of input and output prices used here, is more profitable than cottonseed meal, especially for selling broilers live or processed into cut-up parts. Cottonseed meal can be more profitable than soybean meal at these input and output prices only when broilers are sold as whole carcasses. Cottonseed meal may thus have a new market -- the protein input market for poultry production. Given its availability, the results provided in this study demonstrate that cottonseed meal may be used profitably as an alternative protein source for soybean meal in broiler production, especially when selling as whole carcass birds.

Results for both soybean meal and cottonseed meal formulated rations show that poultry producers could increase profitability by formulating rations that have higher protein levels than the currently recommended levels. Trying to save money by using lower levels of protein in the diet may be costly instead of rewarding.

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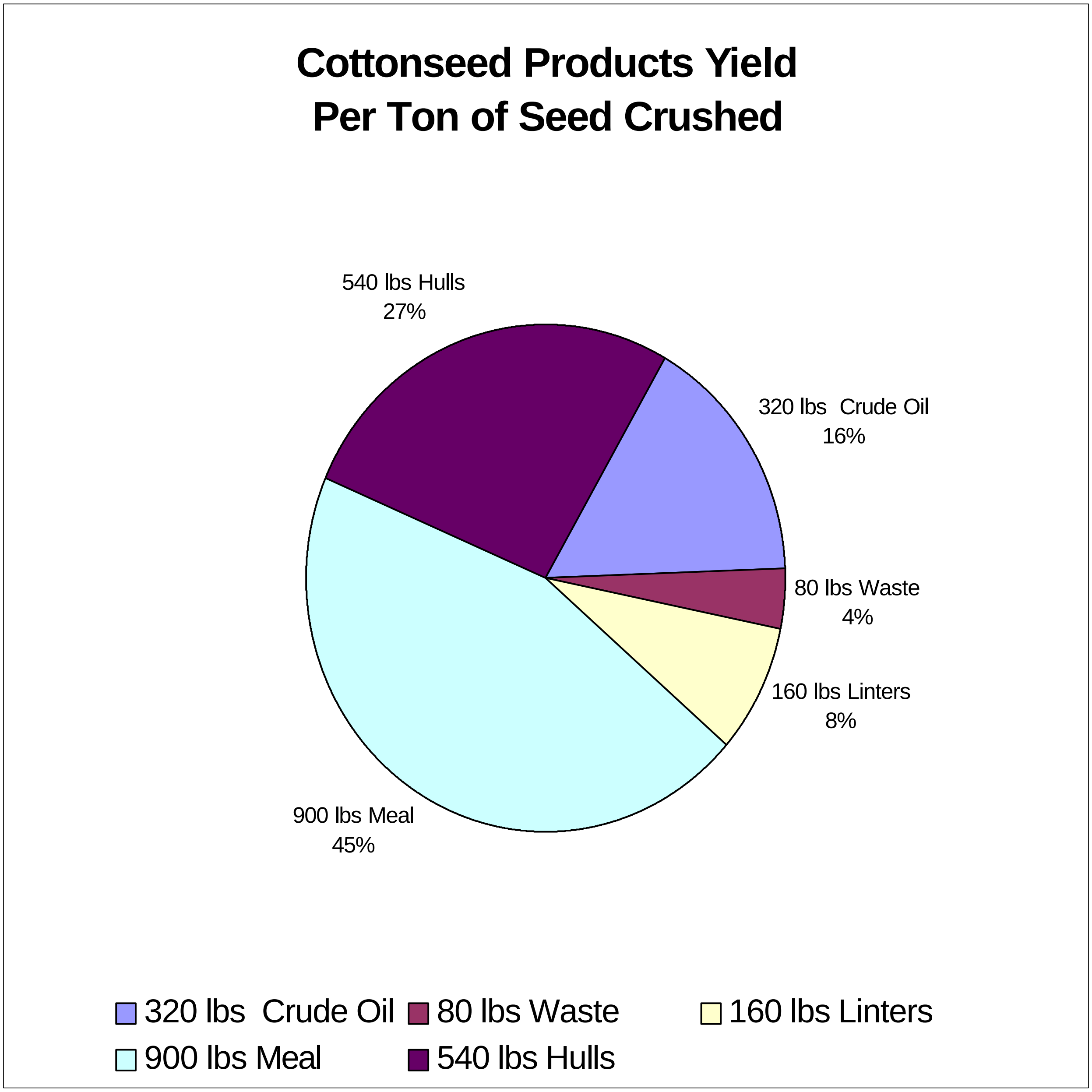

Figure 1. Cottonseed products yield per ton of seed crushed.
Source: National Cottonseed Products Association (NCPA, 1999).

Table 1. Estimated Body Weight, Feed Consumed and Carcass Weight for Broilers Fed Cottonseed Meal and Soybean Meal Protein Based Diets.

	Body Weight (*BW*)		Feed Consumed (F_C)		Carcass Weight (w_{WB})	
Variable	CSM	SBM	CSM	SBM	CSM	SBM
Intercept	-1.8833**	-2.9083**	2.4716**	3.6018**	-343.7263**	-454.2528**
	(0.6722)	*(0.8588)*	*(0.6066)*	*(0.7901)*	*(151.5152)*	*(182.5086)*
F_C	1.7622**	2.1287**	-----	-----	-----	-----
	(0.1128)	*(0.1633)*				
F_C^2	-0.2472**	-0.3259**	-----	-----	-----	-----
	(0.0225)	*(0.0337)*				
t	-----	-----	-0.2495**	-0.2791**	-----	-----
			(0.0129)	*(0.0168)*		
t^2	-----	-----	0.0058**	0.0061**	-----	-----
			(0.0002)	*(0.0003)*		
BW	-----	-----	-----	-----	0.7206**	0.7543**
					(0.0103)	*(0.0130)*
PR	0.0783	0.1412*	0.1397**	0.0858	23.1081	29.1204*
	(0.0588)	*(0.0740)*	*(0.0500)*	*(0.0651)*	*(14.4982)*	*(17.3828)*
PR^2	-0.0012	-0.0026	-0.0034**	-0.0024	-0.4874	-0.6232
	(0.0014)	*(0.0017)*	*(0.0012)*	*(0.0215)*	*(0.3348)*	*(0.4017)*
FE	-0.1487**	-0.1224**	-0.3789**	-0.2337**	7.5580	7.9547
	(0.0260)	*(0.0316)*	*(0.0209)*	*(0.0272)*	*(6.9556)*	*(8.0174)*
R^2	0.9749	0.9620	0.9938	0.9882	0.9815	0.9704
N	60	60	60	60	144	144

Standard errors are in parentheses.

A single asterisk (*) indicates that parameter estimate is statistically significant at the 0.10 level.

A double asterisk (**) indicates that parameter estimate is statistically significant at the 0.05 level.

Table 2. Effects of Live Weight, Protein and Gender on Weights of Cut-up Parts of Broilers Fed Cottonseed Meal.

Variable	Breast	Tender	Leg Quarters	Wings	Fat Pad	Rest of Chicken
Intercept	-161.2719	-55.4677*	-70.2278	-52.5918	46.2808	-73.4742
	(0.4250)	*(31.8000)*	*(119.2025)*	*(49.8008)*	*(59.7482)*	*(122.4894)*
BW	0.1621**	0.0346**	0.3536**	0.0796**	0.0408**	0.0507**
	(0.0078)	*(0.0022)*	*(0.0081)*	*(5.0100)*	*(0.0040)*	*(0.0083)*
PR	9.5551	3.5715	1.6550	5.0107	-5.0374	10.3895
	(10.9639)	*(3.0385)*	*(11.3898)*	*(4.7585)*	*(5.7089)*	*(11.7038)*
PR^2	-0.1918	-0.0654	-0.0740	-0.1157	0.0716	-0.1600
	(0.2533)	*(0.0702)*	*(0.2631)*	*(0.1099)*	*(0.1319)*	*(0.2704)*
FE	9.4799*	5.3276**	-6.3551	4.4625*	15.8314**	-20.7397**
	(5.2993)	*(1.4686)*	*(5.5051)*	*(2.3000)*	*(2.7593)*	*(5.6569)*
R^2	0.8367	0.7502	0.9597	0.8643	0.4931	0.5409
N	144	144	144	144	144	144

Standard errors are in parentheses.

A single asterisk (*) indicates that parameter estimate is statistically significant at the 0.10 level.

A double asterisk (**) indicates that parameter estimate is statistically significant at the 0.05 level.

Table 3. Effects of Live Weight, Protein and Gender on Weights of Cut-up Parts of Broilers Fed Soybean Meal.

Variable	Breast	Tender	Leg Quarters	Wings	Fat Pad	Rest of Chicken
Intercept	-205.7758*	-86.9285**	-72.0462	-59.7433	195.2334**	-275.3197
	(121.6672)	*(26.4681)*	*(130.5123)*	*(44.5443)*	*(51.5384)*	*(116.2331)*
BW	0.1843**	0.0451**	0.3315**	0.0848**	0.0363**	0.0677**
	(0.0088)	*(0.0019)*	*(0.0094)*	*(0.0032)*	*(0.0037)*	*(0.0084)*
PR	10.2014	4.7619*	4.9899	5.1179	-17.7144**	27.5060**
	(11.6186)	*(2.5276)*	*(12.4632)*	*(4.2538)*	*(4.9217)*	*(11.0997)*
PR^2	-0.1842	-0.0869	-0.1379	-0.1187	0.3389**	-0.5667**
	(0.2684)	*(0.0584)*	*(0.2880)*	*(0.0983)*	*(0.1137)*	*(0.2564)*
FE	12.8989**	6.4752**	-18.4337**	0.6087	9.7735**	-5.2683
	(5.3447)	*(1.1627)*	*(5.7333)*	*(1.9568)*	*(2.2640)*	*(5.1060)*
R^2	0.8245	0.8583	0.9362	0.8840	0.5986	0.5182
N	144	144	144	144	144	144

Standard errors are in parentheses.

A single asterisk (*) indicates that parameter estimate is statistically significant at the 0.10 level.

A double asterisk (**) indicates that parameter estimate is statistically significant at the 0.05 level.

Table 4. Reported Prices of Feed Ingredients Used to Find Minimum Feed Cost of the Diets Used in the Scenarios Analysed for Profit Maximization Models.

ingredient	Unit	Date[1]	Price
Corn	$/ton	11/13/00	97.63
Soybean meal - 48%	$/ton	11/13/00	186.00
Cottonseed meal - 42%	$/ton	11/13/00	145.00
Poultry by product meal	$/ton	11/13/00	220.00
Poultry fat	$/ton	11/13/00	215.00
Wheat Middlings	$/ton	11/13/00	64.00
Menhaden Meal	$/ton	11/13/00	337.00
Meat and Bone Meal	$/ton	11/13/00	225.00
Limestone	$/ton	04/20/98	23.00
Defluor. Phos.	$/ton	04/20/98	260.00
Common salt	$/ton	11/13/00	35.00
Vitamin premix	$/ton	04/20/98	5000.00
Mineral premix	$/ton	04/20/98	600.00
DL-Methionine	$/ton	04/20/98	2976.00
L-Threonine	$/ton	04/20/98	2976.00
CuSo4-5H2O	$/ton	04/20/98	992.00
L-Lysine	$/ton	04/20/98	1874.00
Aviax (Coccidiostad)	$/ton	04/20/98	6614.00
Bacitracin	$/ton	04/20/98	4400.00
L-Tryptophan	$/ton	04/20/98	3968.00

[1] Ingredients whose prices were reported on 11/13/00 were collected from Feedstuffs (2000). Ingredients whose prices were reported on 04/20/98 were obtained confidentially from a broiler production company.

Table 5. Reported Prices Used to Analyze the Profitability of Cottonseed Meal and Soybean Meal in the Production of Broilers.

Variable	Date reported	Unit	Value
Whole Carcass[1]	11/22/00	cents/lb	61.50
Skinless Boneless Breast	11/22/00	cents/lb	128.00
Tender	11/22/00	cents/lb	165.00
Leg Quarters	11/22/00	cents/lb	28.50
Wings	11/22/00	cents/lb	78.00
Fat Pad[2]	11/13/00	cents/lb	9.75
Rest of Carcass[3]	---	cents/lb	41.80
Feed delivery cost[4]	---	cents/lb	0.49
Interest Cost[5]	---	%/year	6.00
Offal and Giblets[6]	---	cents/lb	4.00
DOA and Condemnation	---	cents/bird	8.83
Chick Cost	---	cents/chick	20.03
Vaccination, Miscelanious	---	cents/chick	1.40
Processing cost	---	cents/lb	7.50
Further processing cost	---	cents/lb	8.00

[1] USDA Broiler Market News Report is the source of prices for whole carcass, skinless boneless breast, leg quarters, and wings.

[2] Feedstuffs Magazine is the source for the price of Fat Pad.

[3] This price was obtained by taking the weighted average of the price of remaining parts after legs, breasts, giblets and offal were separated from the carcass.

[4] Average Feed Delivery cost reported on Live Production Annual Agri Stats Report (1995), Tables 3.1-1 and 3.1-2.

[5] Annual interest rate assumed.

[6] The remaining costs were obtained confidentially from a broiler production company.

Table 6. Composition of the Optimal Solutions Rations for Soybean Meal and Cottonseed Meal.

	Whole Carcass		Live Bird		Cut-up Parts	
Ingredients and Composition	CSM	SBM	CSM	SBM	CSM	SBM
Ingredients	---------------------------- (%) ------------------------------					
Corn	39.31	49.64	34.98	48.12	37.09	47.14
Soybean Meal	---	25.68	---	26.98	---	27.81
Cottonseed Meal	32.24	---	35.68	---	34.00	---
Wheat Middlings	5.45	5.45	5.45	5.45	5.45	5.45
Menhaden Meal	4.00	4.00	4.00	4.00	4.00	4.00
Poultry Fat	9.96	6.45	10.84	6.68	10.41	6.83
Poultry By-Product Meal	4.00	4.00	4.00	4.00	4.00	4.00
Meat and Bone Meal	3.00	3.00	3.00	3.00	3.00	3.00
Defluor. Phos.	0.62	0.71	0.59	0.70	0.61	0.70
Limestone	0.27	0.14	0.29	0.14	0.28	0.14
Common Salt	0.30	0.30	0.30	0.30	0.30	0.30
Vitamin Premix[1]	0.25	0.25	0.25	0.25	0.25	0.25
DL - Methionine	0.07	0.11	0.08	0.12	0.07	0.12
Mineral Premix[2]	0.08	0.08	0.08	0.08	0.08	0.08
Bacitracin	0.05	0.05	0.05	0.05	0.05	0.05
CuSO4 - 5H2O	0.05	0.05	0.05	0.05	0.05	0.05
L - Lysine	0.19	---	0.20	---	0.20	---
Aviax	0.05	0.05	0.05	0.05	0.05	0.05
L - Threonine	0.10	0.03	0.11	0.03	0.11	0.03
Composition by Calculation[1]						
Protein, %	25.06	24.04	26.22	24.55	25.66	24.85
ME, kcal/kg	3.20	3.20	3.20	3.20	3.20	3.20
Threonine	0.93	0.89	0.97	0.91	0.95	0.92
Methionine	0.48	0.52	0.50	0.53	0.49	0.54
Lysine	1.25	1.34	1.31	1.37	1.28	1.40

[1] Based on NRC (1994) feed composition tables.

Table 7. Scenarios Used to Analyze the Profitability of Cottonseed Meal and Soybean Meal in Broiler Production.

		Whole Carcass		Live Bird		Cut-up Parts	
Variable	Unit	CSM	SBM	CSM	SBM	CSM	SBM
Protein Level	%	25.06	24.04	26.22	24.54	25.66	24.85
Feeding Time (t)	days	37.61	38.57	38.53	38.81	37.86	38.76
Bird weight (BW)	lb	2.26	2.33	2.33	2.35	2.28	2.35
Feed cost (P_F)	cents/lb	16.86	16.81	17.18	16.96	17.02	17.06
Feed consumed (F_C)	lb/bird	2.61	2.60	2.74	2.63	2.63	2.61
Feed conversion ratio	-----	1.16	1.12	1.17	1.12	1.15	1.11
Profit (Π)	cents/bird/day	2.64	2.11	4.48	4.56	2.89	3.25
Equivalent farm price (EFP_B)	cents/lb	64.97	64.29	104.74	104.71	69.15	73.92