Poultry Feeding

1980

PLANNING AND EVALUATING RESEARCH

ON POULTRY NUTRITION:

THE ROLE OF A BIOECONOMIC MODEL+

Kurt K. Klein*, Greig A. Birchfield*,

and Raymond E. Salmon**

Unedited Working Paper
For Discussion Purposes Only

+ Presented to AAEA Annual Meeting, Champaign-Urbana, Illinois, July 27-30, 1980

* Research economist and research assistant, respectively, Agriculture Canada Research Station, Lethbridge, Alberta

** Turkey nutritionist, Agriculture Canada Research Station, Swift Current, Saskatchewan

Abstract

A linear programming model of turkey production was constructed to help in evaluating research results and planning new projects. It maximizes profits per lot subject to nutrient, ingredient, feed quantity, sex ratio, and production capacity constraints. Applications to date include analyses of feeding trials involving various protein sources and establishing priorities for new research.

A major objective of poultry nutrition research is to decrease the real per unit cost of poultry production. Research results are seldom adopted at the farm level unless they increase expected net returns. Many poultry researchers have ignored the economic consequences of their studies, concentrating only on ways of maximizing output. Others have advised producers to minimize feed costs, without fully recognizing that different combinations of inputs can affect both the quantity and the quality of output. However, the overriding concern ought to be the expected level of net returns when interpreting research results and making recommendations on diets and feeding programs.

A bioeconomic model of turkey broiler production was constructed to assist poultry researchers in the evaluation of research results and the planning of new projects. Very close collaboration between researchers in agricultural economics and poultry nutrition was required to permit adequate specification of the model. The model can be applied to any number of experiments involving poultry nutrition, feed manufacturing, or poultry production and marketing strategies.

The linear programming (LP) procedure was chosen for the model because:

1) most agricultural experiments have a small number of discrete treatment levels, thus conforming to the LP structure,
2) LP algorithms are available on most computer systems; they enable rapid solutions which are fairly understandable to scientists and extension personnel,
3) it permits an economical use of resources: the model structure is fixed and standard, thus reducing modelling time, and it can be used with available matrix generator and report writer routines.

The linear programming structure probably does fewer injustices to the interpretation of research results than do other model structures because of the biological research procedures employed. If scientists are worried about linear combinations between two treatment levels, the relevant activities can be integerized and solved with a mixed integer programming (MIP) algorithm. If they are prepared to accept interpolations, then linear combinations will be least objectionable, since generally there are too few observations on the explanatory variables to gain much confidence in any estimated curvilinear function.

Model Structure and Design

The model maximizes profit per lot to a poultry producing operation subject to nutrient, ingredient, feed quantity, sex ratio, and production capacity constraints. Economic and biological data are considered simultaneously. Economic data include feed ingredient prices, labor use and price, poult, energy, and other overhead and operating costs, as well as prices received for each grade and weight class of poultry output. Biological data include feed intake and dietary specifications, liveweights at time of sale, carcass grades, mortality, and, in the case of layers, the quantities and grades of eggs produced. This specification differs from the standard "least cost" formulation in that different quantities and qualities of output are explicitly considered. The model duplicates, in numerical form, the results that have been obtained experimentally, and determines the most profitable of the options available for any set of costs desired.

A matrix generator and report writer routine are integral parts of the model. (In the present case, a matrix generator/report writing computer package was obtained from Haverly Systems, Inc., Denville, New Jersey. This greatly simplified programming requirements.)

The matrix generator permits data to be entered in tabular form, directly from summarized experimental results. The matrix generator includes a set of instructions to transform data, where required, and specifies the matrix location for each coefficient. With only minor modifications, the matrix generator can accomodate a wide range of poultry nutrition experiments.

The items that must be specified in the matrix generator include:

1) number of feeding periods,
2) number of ingredients in each feeding period,
3) number of nutrient constraints,
4) number of feeding programs,
5) number of marketing ages,
6) nutrient constraints (inc. feed intake) by feeding period for each feeding program,
7) mortality rates by feeding program,
8) ratio of males to females,
9) labor and cash use by feeding program,
10) production capacity,
11) prices of ingredients and products (by grade and weight range).

The report writer (in this case, also built upon the Haverly Systems Inc. operating procedures) extracts the useful information from the LP output and displays it in easy-to-read tables. This is especially important for collaboration with research scientists and extension personnel.

In the present version of the model, 5 tables are prepared and printed. The first (Table 1) is an economic summary of the optimal solution, detailing the major cost categories and net returns. (The accompanying tables were taken from an analysis of rapeseed meal in turkey broiler diets; see Klein et al.) Table 2 itemizes the ingredients and total weight of feed required per bird in each of 5 feeding periods (defined, in this case, as 1-3 weeks, 4-6 weeks, 7-9 weeks, 10-11 weeks, and greater than 11 weeks). Table 3 is a calculation from the LP output of the optimal diet per kilogram of feed for each of the feeding periods (plus costs of ingredients and mixing costs). This table, which is not directly available from the LP output, is readily understandable by nutritionists and feed manufacturers. Table 4 provides a constituent analysis of the optimal diet, by feeding period. This table, which again must be calculated from the LP output, enables participating scientists or feed manufacturers to quickly comprehend optimal levels (and possibly surpluses) of key nutrients. The fifth table (not shown) provides information on penalty costs of alternative (non-optimal) feeding programs. Other shadow price or penalty cost information that may be desired can be easily added at this point, since they are taken directly from the LP output.

Applications of the Model

The model has had its most extensive testing in an evaluation of low glucosinolate rapeseed meal in turkey broiler diets (Klein, et al.). Rapeseed meal is a byproduct of the process of extracting oil from rapeseed. A greater use of rapeseed meal would have important economic implications for Canada since a domestically produced protein supplement could replace a portion of an imported protein supplement (soybean meal).

In this experiment, 1000 sexed turkeys were fed diets comprised of 4 levels of rapeseed meal, each split into 3 levels of nutrient density. The turkeys were marketed at 12, 13, and 14 weeks of age. Diets were changed 5 times as the turkeys grew (as per Tables 2,3,4). Thirteen feed ingredients provided the nutrient sources available for feed formulation. Records were kept of feed consumption, mortality, liveweights, and carcass quality.

The economic evaluation of these data showed that rapeseed meal could profitably be used at substantially higher levels (under most reasonable price conditions) than had previously been recommended by nutritionists and feed manufacturers. Rapeseed meal has a small adverse effect on growth rates when fed at high levels - this had inhibited use of the product. However, given the usual price advantage of domestically produced rapeseed meal over imported soybean meal, it was often most profitable to forgo maximum growth rates by increasing the proportion of rapeseed meal in the diet and marketing the birds at a slightly greater age (usually a matter of 1-3 days).

The economic evaluation of the turkey broiler experiment inspired a further study on the use of low glucosinolate rapeseed meal in chicken broiler diets (Salmon, et al. 1980). In this experiment 2160 chicks were fed diets consisting of 4 levels of rapeseed meal (plus control), with 2 protein and 2 nutrient density treatments. In one, nutrient density is maintained by added fat as rapeseed meal is increased; in the other, the level of added fat remained constant and nutrient density decreased with increased levels of rapeseed meal. The chicks were marketed at 7 and 8 weeks of age.

Minor modifications to the matrix generator and report writer were all that was needed to analyze the results of this experiment. The economic evaluation provided additional evidence that low glucosinolate rapeseed meal is a much more competitive feed ingredient in poultry diets than was previously thought.

Biological data from 3 experiments on the use of fababeans in broiler chicken diets (Gardiner et al.) were evaluated together, using a modification of the bioeconomic poultry production model. One experiment included 2 levels of methionine and 2 levels of lysine. The second experiment included 21 diets composed of 4 varieties of fababeans, each grown at 5 levels of nitrogen fertilizer. One diet contained no fababeans. The third experiment considered 4 varieties of fababeans at 2 levels in the diet (20 and 40 percent) under 2 levels of energy. Two control diets (one for each energy level) were also included.

The economic evaluation showed that fababeans were not competitive in broiler chick diets. The price ratio between fababeans and soybeans would have to be much lower than any experienced over the past several years before even a small proportion of the optimal diet would include fababeans.

The model was also modified to evaluate alternative levels of feed restrictions and energy content on laying hens (unpublished data). Quantities and grades of eggs varied by treatment throughout the 48 week test period. The economic analysis showed that some level of feed restriction was optimal under most reasonable conditions.

Another application that is nearing completion concerns the effects of dietary protein concentration and frequency of diet changes on the production of large white turkeys (Salmon and Wilson). This experiment, conducted in Scotland, includes 8 feeding periods, 12 feeding programs, and 5 marketing ages for each of male and female turkeys. As before, only minor modifications to the matrix generator and report writer were necessary to permit an economic evaluation of these data.

An important use of a model of this type is in establishing priorities for research. Poultry nutritionists can examine the sensitivity of optimal feeding programs to hypothesized data in areas where they lack specific knowledge. A current area of interest concerns the need for further experimentation on potential gains from varying the proportion of rapeseed meal in poultry diets by feeding period. By freeing the constraints enforcing the same quantity of rapeseed in each feeding period, one could determine the utility or futility of committing research resources to investigate the relevant feed-weight relationships.

The model has important applications in the extension area. Too often, poultry management and feed nutrition recommendations have been made in the absence of any economic criteria. And, when economic criteria have been used, they have often been of a least cost rather than a maximum profit nature.

Concluding Note

The construction and use of this model has shown that cooperative research efforts between biological scientists and economists can result in more valuable research output for a given level of research expenditure than would normally result from the separate use of the same resources. The usual method of funding biological researchers to study the profitability of feeding various combinations of ingredients with no provision for feeding trials would seldom permit as sharp a focus on the pertinent question of economic efficiency. It is hoped that this study will spawn more efforts of this nature.

References

Gardiner, E., S. Dubetz, and G. Kemp. "Growth Responses of Chicks Fed Fababeans Diets." Can.J. Anim. Sci. (forthcoming)

Klein, Kurt K., Raymond E. Salmon, and M. Elizabeth Larmond. "A Linear Programming Model for Determining the Optimal Level of Low Glucosinolate Rapeseed Meal in Diets of Growing Turkeys", Can.J. Agr. Econ. 27(3):74

Salmon, R.E. and B.J. Wilson. "Influence of Dietary Protein Concentration and Frequency of Diet Changes on Rate of Growth and Efficiency of Food Utilization of Large White Turkeys", unpublished manuscript, Agri. Can. Res. St., Swift Current, Sask., Canada, 1978.

Salmon, R.E., E. Gardiner, and K.K. Klein. "Effect of Low Glucosinolate Rapeseed Meal, Protein and Energy on Performance, Carcass Quality and Meat Yield of Broilers," unpublished manuscript, Agric. Can. Res. St., Swift Current, Sask., Canada, 1980.

SWIFT CURRENT TURKEY RATION PROJECT

TABLE 1. ECONOMIC SUMMARY

	MALES	FEMALES	TOTAL
NO. SOLD	87.271	92.681	179.952
AVE.WGT(KG.)			5.455
% GRADE A BIRDS SOLD			81.413
FEED EFFICIENCY(KG FEED/KG SOLD)			2.317
% MORTALITY			10.024
% CONDEMNATION			1.000
AVG. SELLING PRICE($/BIRD SOLD)			5.830
CASH COSTS($/BIRD SOLD)			2.390
CASH COSTS($/BIRD PURCHASED)			2.150
LABOUR COST($/BIRD SOLD)			.385
LABOUR COST($/BIRD PURCHASED)			.347
FEED COSTS($/BIRD SOLD)			2.593
FEED COSTS($/BIRD PURCHASED)			2.474
FEED COST($/KG BIRD SOLD)			.475
NET RETURN($/BIRD SOLD)			.462
NET RETURN($/BIRD PURCHASED)			.416
NET RETURN($/KG BIRD SOLD)			.085
AGE BIRDS SOLD(WEEKS)			13.530

TABLE 2. FEED REQUIRED(KG/TURKEY),BY FEEDING STAGE

	STAGE 1	STAGE 2	STAGE 3	STAGE 4	STAGE 5	TOTAL
WHEAT	.323696	1.051908	2.040211	2.074585	3.211793	8.702192
SOYBEAN MEAL	.181027	.428014	.585673	.226053	.180748	1.601515
RAPESEED MEAL	.048132	.137334	.235239	.204974	.301375	.927554
MEAT MEAL	.032067	.091493	.157038	.136835	.201524	.618958
FISH MEAL	.032067	.055009				.087075
DYNAFOS	.012782	.030142	.047607	.034160	.034850	.159541
CALC-CARB	.004831	.015775	.027533	.022871	.038467	.109477
SALT	.001607	.004584	.007852	.006842	.010076	.030961
FAT	.016059	.046308	.079154	.068752	.105821	.316094
PMX72A	.002787	.008251	.014614			.025653
PMX72B				.005501	.008184	.013686
METOL	.000699	.002224	.004687	.003677	.005200	.016488
LYSINE HCL			.005262	.008311	.014194	.027767
TOTAL	.655753	1.871043	3.204871	2.792561	4.112732	12.636960

TABLE 3. OPTIMAL DIET,BY FEEDING STAGE

	COST ($/TONNE)	RATION(GRAMS PER KG FEED) STAGE 1	STAGE 2	STAGE 3	STAGE 4	STAGE 5
WHEAT	100.	493.625	562.204	636.597	742.897	780.939
SOYBEAN MEAL	275.	276.059	228.757	182.745	80.948	43.948
RAPESEED MEAL	175.	73.399	73.400	73.407	73.400	73.400
MEAT MEAL	285.	48.900	48.900	49.000	49.000	49.000
FISH MEAL	660.	48.900	29.400			
DYNAFOS	267.	19.492	16.110	14.855	12.233	8.474
CALC-CARB	28.	7.367	8.431	8.591	8.190	9.353
SALT	86.	2.450	2.450	2.459	2.450	2.450
FAT	500.	24.490	24.750	24.698	24.620	25.730
PMX72A	1329.	4.250	4.410	4.560		
PMX72B	619.				1.970	1.990
METOL	3410.	1.067	1.189	1.463	1.317	1.264
LYSINE HCL	3925.			1.642	2.976	3.451
COST OF INGR.($/TONNE)		211.49	192.35	174.98	156.77	151.68
FEED COST($/TONNE)		241.49	222.35	204.98	186.77	181.68

TABLE 4. CONSTITUENT ANALYSIS OF OPTIMAL DIET, BY STAGES

	CALCULATED ANALYSIS (PER KG)				
	STAGE 1	STAGE 2	STAGE 3	STAGE 4	STAGE 5
MET.ENERGY	2803.000	2809.000	2796.999	2838.000	2859.999
TRUE MET.ENERGY	3074.400	3080.673	3067.233	3111.472	3135.336
PROTEIN	285.000	260.000	231.000	201.000	190.000
FAT	48.398	48.052	46.776	47.796	49.296
FIBRE	29.285	29.576	30.036	29.692	29.552
CALCIUM	12.620	11.740	10.780	9.790	9.310
PHOSAVAL	8.440	7.340	6.470	5.870	5.090
METHIONINE	5.964	5.437	4.839	4.237	4.018
CYSTINE	5.006	4.573	4.051	3.503	3.302
METH.+CYST.	10.970	10.010	8.890	7.740	7.320
LYSINE	16.734	14.363	12.710	11.060	10.450