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LEAST-COST LIVESTOCK PRODUCTION RATIONS

John R. Allison and D. M. Baird

INTRODUCTION

Animal scientists and agricultural economists have been working together to answer the question, "What is the least-cost feed mix for a given set of prices?" In the 1950's sophisticated mathematical programming via computers generated a renewed interest in ration formulation. Since then, animal scientists and agricultural economists have been intrigued with determining least-cost rations for various livestock species.¹ But this research has been devoted to determining the least-cost rations rather than minimizing feed cost per pound of gain or pound of product produced and/or minimizing total cost per pound of gain or product produced.² Answering the latter question is a prime goal of animal nutrition research.

THE PROBLEM

The practice of minimizing feeding ingredient costs for pre-established rations rather than minimizing feed cost per unit of product produced has contributed to a deficiency in the data needed for estimation of production functions for livestock feeding. This practice also has encouraged livestock producers to feed for maximum production per unit regardless of feed ingredient prices, since the minimum quality restraints used, such as amino acids, have generally been those restraints which allow maximum growth or production. In their research determining least-cost feed mixed with probability restrictions, Rahman and Bender [11] were concerned about inadequate knowledge of the

relationship of protein level and failure rate in poultry nutrition.

Dairymen and cattle feeders realize that feeding for maximum production is not always the most profitable practice, but have few guidelines for determining least-cost production rations. A recommended dairy feeding practice is to test forages for energy and protein and then prepare a least-cost ration that provides a pre-established energy and protein level. Many cattle feeders are feeding least-cost rations designed to provide a given average daily gain.

Specified minimum requirements of amino acids and energy levels are generally accepted in swine nutrition [9]. Nutrition research has been conducted with the goal of determining those levels of energy and protein which provide the highest physical growth rate and lowest feed conversion ratios. Recently, high costs of protein and energy have spurred researchers to re-evaluate past efforts. Bitney and Moser [2] and Carlisle [4] performed some preliminary analyses evaluating the consistencies of current recommended feeding practices with high protein cost. But, as in other studies, the final step of determining optimum combinations of protein and energy and the corresponding feed mix that minimizes feed cost for specified input prices was not completed. We have accepted some growth or production rate as optimum and are not determining which protein and energy levels are most profitable for various input and product prices. Although specifying total production functions may be

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¹ Brown and Arscott [3] have an extensive listing of least-cost ration research efforts published prior to 1960.

² Minimizing feed cost per pound of gain is sufficient in those conditions where the alternatives being considered do not increase fixed cost, labor, and/or animal cost by prolonging the feeding period appreciably and/or reducing the present value of the future earnings from future lots of animals by extending the feeding period of the present lot. Minimizing feed cost per animal as used in this manuscript means producing a specified quality and amount or quantity of product at a minimum cost — not determining the lowest cost growth period of the animal.

infeasible, historically we have not attempted to deduce the relationships existing over a small segment of the production surface.

Swine nutritional data and current recommended feeding practices demonstrate the problem. Considerable research shows the effect of varying energy and protein levels on feed conversion and gain for swine, [1, 5, 6, 7, 8, 12, 13]. However, little nutritional research has been directed at the influence of simultaneous protein and energy level variations on feed conversion and average daily gain. Animal nutrition research has not been influenced by analyses of least-cost rations to the extent that data from the nutritional studies provide relevant gain and feed conversion ratios for specific protein and energy levels by growth stages of livestock. The shortage of data is even more critical with amino acids. Research efforts analyzing the amino acid levels have determined those levels of specific amino acids which provide maximum physical growth. Therefore, the final step of determining those optimum protein and energy levels which minimize feed cost requires an interpretation of the results of past research.

Swine rations were used as the vehicle to present an extension of least-cost rations. This extension permits protein and energy to be variables in optimum ration determination. Changing the length of the feeding period (or average daily gain) changes labor and overhead costs and provides a potential for loss or gain in value of the finished swine because of price changes during an extended feeding period. The effects of these other costs were analyzed by including variables of labor costs, overhead cost, and difference in the price of finished swine in the models.

PROCEDURE

Data from four swine feeding studies and/or analyses of feeding studies provided data to estimate the relationships of feed conversion and gain with crude protein and energy (metabolizable calories per pound) levels for two growth stages [1, 4, 6, 12]. The growth stages chosen were: 40-125 lbs. and 125-210 lbs. The average daily gain and feed required per pound of gain for four crude protein levels (10, 12, 14, and 16 percent) and for three metabolizable

Table 1. FEED CONVERSION, AVERAGE DAILY GAIN AND DAYS REQUIRED TO PRODUCE 85-POUND INCREMENT PER ANIMAL BY PROTEIN AND ENERGY LEVEL FOR TWO WEIGHT CLASSIFICATIONS OF SWINE^a

Swine weight classification (pounds)	Percent crude protein											
	10			12			14			16		
	Energy level ^b											
	low	med.	high									
Feed/gain ratios												
40-125	3.65	3.55	3.45	3.15	3.10	3.00	3.10	2.95	2.70	3.00	2.85	2.60
125-210	4.65	4.55	4.35	4.05	4.00	3.80	3.90	3.75	3.40	3.80	3.65	3.30
Average (40-210)	4.15	4.05	3.90	3.60	3.55	3.40	3.50	3.35	3.05	3.40	3.25	2.95
Average daily gain (pounds)												
40-125	1.25	1.30	1.35	1.45	1.45	1.45	1.50	1.50	1.50	1.55	1.55	1.55
125-210	1.55	1.60	1.65	1.75	1.75	1.75	1.80	1.80	1.80	1.85	1.85	1.85
Average (40-210)	1.40	1.45	1.50	1.60	1.60	1.60	1.65	1.65	1.65	1.70	1.70	1.70
Days required to produce 85 pounds												
40-125	68	65	63	59	59	59	57	57	57	55	55	55
125-210	55	53	52	49	49	49	47	47	47	46	46	46

^aCoefficients were estimated values determined from results of selected nutritional studies [1, 4, 6, 12].

^bEnergy levels are: low, 1,275; medium, 1,425, and high, 1,575 calories of metabolizable energy per pound of feed.

energy levels (1,275, 1,425, and 1,575 calories per pound of feed) are presented in Table 1.

Feed conversion ratios were used to transform each of the specific crude protein and energy level combinations into the pounds of feed required per pound of gain for the specific combinations. The same minimum requirements of vitamins and minerals were used in all rations.

The minimum levels of amino acids were assumed to vary proportionately with protein level. Data from previous research provided insufficient information to permit the estimation of more exact functions. The minimum level of a specific amino acid was reduced by the same ratio as the protein reduction; e.g., minimum amino acid levels for the 12 percent ration were 75 percent of the minimum levels of the respective amino acids used for 16 percent crude protein ration. The minimum amino acid levels used in the 16 percent ration were as follows: Lysine .65, Tryptophane .09, Methionine .26, and Cystine .44 percent.

Previous research does not indicate any response in average daily gain to increases in energy levels for a given protein level for moderate or high protein levels [12]. Thus, the average daily gain rates (and the resulting days required to produce 85 lbs. of pork) used in the analyses (Table 1) do not vary among energy levels for the 12, 14, and 16 percent crude protein levels for a given swine weight classification.

The linear programming formulation of the least-cost model allowed any of 12 ration specifications to be chosen or any combination of two or more to be chosen. Thus, instead of 12 rations, a continuous range of rations with crude protein from 10 to 16% and metabolizable energy per pound from 1,275 to 1,575 calories was possible.

January 1974 feed ingredient prices were used in the analyses. Corn was priced at \$.054 and 44-percent soybean oilmeal at \$.120 per pound.

The average daily gain determined the number of days required for swine to attain a specified weight (see Table 1). Each additional day in the feedlot adds to the labor cost. Thus, a labor activity was added with a cost of \$.08 per swine day. A longer feeding

period also increased the overhead cost per head. An overhead activity was added at a cost of \$.013 per swine day³ (overhead costs consisted of ownership and operating costs of housing, feeding floor, feed processing and handling, storage, and waste disposal facilities).

In some situations, increasing the days on the feeding floor may reduce the price received for the finished swine because of a seasonal price decline during the extra length of the feeding period.⁴ Unfortunately, data related to seasonal price variations are not conclusive. Purcell and Elrod [10] projected U.S. farm price of swine by months for 1972-1977. An activity was included using their largest projected reduction in price during a 30-day period of \$1.08 per hundredweight.⁵

RESULTS

Minimizing total feed cost for adding 170 lbs. (finishing swine from 40-210 lbs. - Model 2, Table 2) decreased the cost per head \$6.35 from the cost obtained by minimizing feed ingredient cost for pre-established protein and energy levels (Model 1 - Table 2). The ration which minimized feed costs per pound of gain had 12 percent crude protein and 1,275 metabolizable calories per pound. This was lower than 16 percent crude protein for 40-125 lbs. and 14 percent for 125-210-lbs. swine and 1,575 metabolizable calories for both weight groups used in Model 1 which represented current feeding recommendations for swine [2, 4, 9].

In this analysis, labor and overhead costs had little influence on determining the protein or energy level of rations or the ingredients included in the ration (Model 3). Before either labor or overhead costs would influence the least-cost ration, the sum of these costs would have to measure to \$.250 and \$.265 per hundredweight for the 40-125 and 125-210 weight groups, respectively, or 269 and 285 percent of the \$.093 used in the analyses. The potential price loss that could occur during extended feeding periods had no influence on the least-cost ration with January 1974 costs. A price decrease of \$.017 and \$.016 per hundredweight per day would have to occur

³These costs were estimated from data provided by a selected group of Georgia swine producers. Labor was costed at \$2 per hour.

⁴Adjusting the starting time of a feeding period would be the appropriate method of handling an expected seasonal price increase.

⁵The maximum per month reduction used was \$1.08 per hundredweight of swine even though Purcell and Elrod did not find any of their monthly deviations from the base month to be significantly different from zero at the five percent level. This activity was included to show the potential influence of seasonal swine prices and assumed an average per-day decline over a month period. A swine ration increasing the days on feed 10 days beyond the days the maximum average daily gain ration required for a swine to reach 210 lbs. would have an extra cost of 10 times the average daily price cost of \$.074 per hundredweight or \$.74.

Table 2. PROTEIN AND ENERGY LEVEL OF RATIONS AND COST OF FEEDING OUT SWINE BY MINIMIZING FUNCTIONS

Model (minimizing function ^a)	Swine weight lb.	Crude protein of ration %	Metabolizable energy cal/lb.	Average daily gain lb.	Feed/gain ratios lb.	Feed cost 16.71	Labor cost 4.40	Overhead cost .70	Price ^b dollars	Total cost of gain
Model 1 feed ingredient cost	40-125	16	1575	1.55	2.60	16.71	4.40	.70	0.00	21.81
	125-210	14	1575	1.75	3.40	20.36	3.76	.60	.00	24.72
	Average (40-210)	-	-	1.65	3.00	37.07	8.16	1.30	.00	46.53
Model 2 Feed costs	40-125	12.0	1275	1.45	3.15	12.96	4.72	.76	.30	18.74
	125-210	12.0	1275	1.75	4.05	16.67	3.92	.63	.22	21.44
	Average (40-210)	-	-	1.60	3.60	29.63	8.64	1.39	.52	40.18
Model 3 feed, labor, overhead and price costs	40-125	12.0	1275	1.45	3.15	12.96	4.72	.76	.30	18.74
	125-210	12.0	1275	1.75	4.05	16.67	3.92	.63	.22	21.44
	Average (40-210)	-	-	1.60	3.60	29.63	8.64	1.39	.52	40.18

^aCost item minimized in the respective models. Model 1 is consistent with current swine feeding recommendations. Feed ingredient costs per pound of feed mix were minimized with energy pre-established at 1,575 calories per pound of ration and protein levels pre-established at 16 percent for the 40-125- and 14 percent for the 125-210-lb. group. Feed costs per pound of gain were minimized in Model 2 and the sum of feed, labor, overhead, and price costs per pound of gain were minimized in Model 3.

^bCost associated with a decrease of \$1.08 per hundredweight over a 30-day period pro-rated over the increase in days feeding required as rations depart from maximum average daily gain ratios (16 percent crude protein and 1,575 metabolizable calories per pound).

respectively for 40-125 and 125-210 weight groups before a price decline would influence the optimum protein and energy level.

Analyses using January 1973 and January 1974 feed ingredient prices emphasize the advantage of minimizing feed cost per pound of gain compared to the traditional procedure of minimizing ingredient cost for specified levels of energy and protein. With January 1974 prices, total cost of adding 170 lbs. to a 40-pound feeder pig is increased more by increasing the energy level of the ration than by increasing the crude protein level. Similar analyses using January 1973 prices showed the reverse — it costs less to increase the energy levels than to increase protein levels. In the analyses using January 1973 prices of feed ingredients and minimizing feed cost for the production of 170 lbs. of pork per head, the minimum feed cost per pound of gain ration had a medium level of energy compared with the low energy level using January 1974 prices. Thus, feeding low energy rations in 1973 would have increased costs over the feeding of medium energy level rations.

CONCLUSIONS

Although these analyses are limited due to

discrepancies and/or limited feed conversion and gain data from nutritional studies, the results reported in this study demonstrate that minimizing feed ingredient cost for pre-established rations may not be a sufficient criterion for minimizing cost and maximizing profits in swine feeding operations. The ingredient cost also should determine the crude protein level and the energy level of the ration. In this study, January 1974 labor cost, overhead cost, and expected seasonal price patterns were such that these three factors had minimum influence on determining crude protein and energy level of minimum cost rations.

These analyses suggest that swine producers should evaluate changing rations with changes in the feed ingredient prices. The analyses also suggest that researchers should add a new emphasis to their nutritional work, and design feeding trials to provide feed conversion and gain data for several combinations of protein and energy levels. This emphasis should be added to all animal nutrition work. Poultry producers need data that provides the bases for calculation of the most profitable energy and protein levels for all relevant ranges of input prices. Feedlot operators need to know the most

profitable rations and the resulting daily gain for a given set of feed ingredient prices. Milk producers need to know the most profitable level of feeding for specific feed ingredient prices. Emphasis needs to be

placed on amino acid research, particularly in swine and poultry nutrition, as crude protein level is meaningful only as an indicator of the levels of amino acids.

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