ECONOMIC ANALYSIS OF BROILER LITTER AS A FEED FOR STEERS

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Approximately 50 million metric tons of poultry wastes are produced annually in the United States. Production of this byproduct is not without costs. Cost incurred for handling and disposal of broiler litter, for example, has been estimated to be .26¢ per kg of liveweight salable bird [1].

Although costs are associated with this byproduct, it is not a source of revenue for many producers. The traditional use of litter has been as a fertilizer. However, for many poultry producers, land is a limiting factor. In some cases, the value of the plant nutrient content of the wastes does not justify their use instead of commercial fertilizers when handling costs are considered. Thus in many instances these wastes create a pollution problem and may be negatively priced.

A possible alternative use for poultry wastes is as a feed for ruminants. The efficacy of feeding poultry wastes to ruminants has been established [2, 3, 5]. Thus, if litter is an economic alternative feed, the revenue situation for poultry producers and cost conditions for beef producers may be changed.

The major objective of the research reported here is to determine the technical and economic relationship between broiler litter and other feeds used in steer production. In addition, least-cost rations are presented for comparison of feed costs of "conventional" rations with those of broiler litter. Finally, profit conditions for broiler producers are examined in terms of alternative broiler litter prices.

METHODOLOGY

Production Functions

One method by which the technical relationship between broiler litter silage (BLS hereafter) and other feeds can be ascertained is from the production function. Alternative forms of production functions were fitted with data obtained from a feed performance study.

Eighty steers (cross-bred and straight-bred Angus) were assigned randomly by weight and biological type to one of five dietary treatments. Each treatment consisted of four replications (pens) containing four steers per replication. Treatment composition (on a dry matter basis) was 30 percent concentrate plus: treatment 1 (T1), 70 percent corn silage (CS); T2, 60 percent CS and 10 percent BLS; T3, 40 percent CS and 30 percent BLS; T4, 20 percent CS and 50 percent BLS; T5, 70 percent BLS. The steers were given a one-week adjustment period and were fed their respective ration for a 200-day feeding period. Feed consumption was recorded at weekly intervals and the steers were weighed at 28-day intervals.

Different forms of production functions were fitted with data from treatments T2, T3, and T4. Treatment T1 was excluded because of zero input levels for BLS, and T5 was excluded because the steers went "off their feed" and the ration composition had to be changed.

The generalized form of the production functions was:

$$(1) \qquad Y = f(X_1, X_2) + \varepsilon$$

where

Y = total gain per steer measured from the beginning of the feeding period to a weighing period

X_1 = total corn silage intake from the beginning of the feeding period to a weighing period

X_2 = total BLS intake from the beginning of the feeding period to a weighing period.

Because concentrate was fixed at 30 percent of the ration (dry matter basis), it could not be included as a variable. Each function was fitted with and without intercepts, i.e., through the origin. Criteria for selecting functions were based on statistical significance of the independent variables as well as the logical consistency of the signs of the independent variables.

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Least-Cost Rations

Because of the experimental design of the feed performance study, no relationship between BLS and concentrates could be determined from the production function approach. As BLS is very high in crude protein equivalent, it is a potential substitute for relatively high priced forms of concentrates [2, 3, 5]. For this reason and to obtain an estimate of the effect on feed costs of substituting BLS for both concentrates and other feeds, least-cost rations were also developed.

Least-cost rations were computed for taking a steer from 200 to 500 kg. Because nutrient requirements change as the weight of the animal changes, rations were developed for each of the following weight categories: W1, 200-249 kg; W2, 250-299 kg; W3, 300-349 kg; W4, 350-399 kg; W5, 400-449 kg; and W6, 450-500 kg.

Nutrient requirements for each weight category were those necessary for an average daily gain of .91 kg as defined in [4]. The exception was the dry matter requirement. It was changed to reflect the results of the feed performance study which indicated that steers fed litter had a higher dry matter intake. Results of the study showed a 12 percent increase in dry matter consumption for rations containing litter [2]. This increase was attributed to the high ash content in the litter. Thus, for those rations in which litter was included, a range was established on the dry matter requirement. The minimum dry matter requirement was that defined by the National Research Council [4] and the maximum reflected a 12 percent increase.

Least-cost rations were developed for each weight level from the following feeds:[1] corn silage, 2.31¢/kg [5]; corn, 9.55¢/kg [7]; cottonseed meal urea mix of comparable protein value to BLS (i.e., 67 percent cottonseed meal and 33 percent urea), 24.86¢/kg;[2] BLS, 0.97¢/kg.[3] Rations were developed with alternative constraints on BLS which were set at zero and less than or equal to 10, 30, and 50 percent of the total ration (dry matter basis).

RESULTS

Production Functions

Of the functions fitted, the following one was selected on the basis of statistical significance of the independent variables and their conformance to production theory.

$$(2) \qquad \hat{Y} = X_1^{.49} X_2^{.25}$$
$$R^2 = .99.$$

Respective t-statistics for X_1 and X_2 were 24.07 and 10.62. Each variable was significantly different from zero at the 99 percent confidence level with 130 d.f.

The equation for a gain isoquant was calculated from the production function. The equation obtained was:

$$(3) \qquad X_2 = \left[\frac{\hat{Y}}{X_1^{.49}} \right]^4.$$

The marginal rate of technical substitution of X_1 for X_2 ($MRTS_{X_1.X_2}$ hereafter) was estimated to be:

$$(4) \qquad -\frac{dX_2}{dX_1} = 1.96 \frac{X_2}{X_1}.$$

Presented in Table 1 are corn silage (X_1) and BLS (X_2) combinations that will yield a 50-kg gain isoquant with concentrate at 30 percent of the ration on a dry matter basis. Also shown in Table 1 are the feed costs for X_1 and X_2 (i.e., $P_{X_1}/P_{X_2} = 2.38$) and the $MRTS_{X_1.X_2}$ at their respective levels.

TABLE 1. INPUT COMBINATIONS, $MRTS_{X_1.X_2}$ AND COSTS FOR A 50 KG GAIN ISOQUANT

$X_1{}^a$	$X_2{}^a$	$MRTS_{X_1,X_2}{}^a$	Costs
-------------	--------(kg)-------------		(Dollars)
100	751	14.72	9.58
150	339	4.43	6.74
200	193	1.89	6.47
250	125	.98	6.96
300	87	.57	7.74
350	64	.36	8.67
400	50	.25	9.69
450	39	.17	10.73
500	32	.13	11.81
550	27	.10	17.98

$^a X_1$ is CS, X_2 is BLS and $MRTS_{X_1.X_2} = - dX_2/dX_1$.

The least-cost combination for producing 50 kg of gain was estimated to be 184 kg of X_1, 223 kg of X_2 at a cost of $6.41. Total feed cost with corn as the concentrate was $16.35. Ration composition for this mix on a dry mat-

ter basis was X_1, 24 percent; X_2, 46 percent; corn, 30 percent. The $MRTS_{X_1, X_2}$ at this input combination was estimated to be 2.37.

Least-Cost Rations

Feed costs per kilogram of gain was computed by a least-cost minimization algorithm are presented in Table 2 by weight category for

TABLE 2.   FEED COSTS PER KG OF GAIN BY WEIGHT LEVEL FOR ALTERNATIVE UPPER LIMITS ON BROILER LITTER SILAGE[a]

Weight Level[c]	Upper Limits on BLS[b]			
	0	10	30	50
	----------(Cents/kg)----------			
W1	42.24	36.96	28.60	27.06
W2	48.84	42.24	33.22	29.48
W3	58.96	50.60	39.16	37.91
W4	58.96	51.04	42.90	38.50
W5	60.50	54.34	48.40	45.34
W6	65.56	57.42	50.82	44.22
Average	55.88	48.80	40.48	36.52
	----------(Dollars)----------			
Total Feed Costs	168.14	146.96	121.80	109.89

[a]W1, 200-249 kg; W2, 250-299 kg; W3, 300-349 kg.; W4, 350-399 kg; W5, 400-449 kg; W6, 450-500 kg.

[b]Maximum percentage of broiler litter silage permitted in the ration (dry matter basis).

[c]Least-cost rations were developed from the following feeds: corn silage, 2.31¢/kg; corn, 9.55¢/kg; cottonseed meal-urea mix, 24.96¢/kg; and BLS, 0.97¢/kg.

alternative constraints on BLS. Note that feed costs decreased, for each weight level, as the upper limit on BLS was increased. Dollar savings was greatest at the 10 and 30 percent upper limits on BLS. Although costs were reduced when the upper limit was increased from 30 to 50 percent, the savings were not as great. The reason for this outcome is that as BLS was brought into the ration at the 10 - 30 percent upper limits, it was substituting for the relatively higher priced cottonseed meal urea mix and for primarily corn silage thereafter. For example, in the weight category W1, the first kilogram of litter to enter the ration (i.e., constraint increased from zero to an upper limit of 10 percent) substituted for .19 kg of cottonseed meal urea mix and .81 kg of corn silage for a net reduction in feed costs for each kilogram of litter brought in of 5.73¢/kg. However, for this same weight level, as the constraint is increased from 30 to 50 percent, bringing an additional kilogram of litter reduced feed costs by only .85¢/kg of litter.

Total and average feed costs per kilogram

for taking a steer from 200 to 500 kg are also presented in Table 2. At the zero constraint, total feed costs were computed to be $768.14 for a cost per kilogram gain of 56.05¢/kg. These costs were considerably higher than those incurred at the 50 percent upper limit. Total feed costs when BLS was constrained to zero were 53 percent greater than feed costs incurred with a 50 percent upper limit on BLS. As the upper limit on BLS was increased from zero to 10 percent, zero to 30 percent, and zero to 50 percent, savings in feed costs for taking the steer from 200 to 500 kg were, respectively, $21.18, $46.34, and $58.25. Clearly the use of BLS as a feed produces considerable savings in the feed costs even when constrained to a relatively low percentage of the ration.

IMPLICATIONS

Beef Producers

The use of BLS as a feed provides considerable savings in feed costs to beef producers. At the foregoing set of prices, feed costs could be decreased by as much as 35 percent by feeding rations containing 50 percent BLS. However, one would expect these cost savings to become smaller as more and more beef producers use these wastes as a feed and consequently bid up the price of broiler litter.

Broiler Producers

Profit conditions for broiler producers will change as litter moves to a higher and better use. Because broilers and litter are produced in fixed proportions, a composite price can be defined and profit maximizing conditions expressed in terms of one of the products. Let conditions faced by broiler producers be expressed as:

(5) $Y_L = \alpha Y_B$,
(6) $P^* = P_B Y_B + P_L \alpha Y_L$, and
(7) $\pi = P^* Y_B - C(Y_B) - FC$

where

Y_L = kg of broiler litter produced
Y_B = kg of broilers produced on a live-weight basis
α = the proportion in which broilers and litter are produced; α = .855 [2], that is, for each kg of bird produced, .855 kg of litter is produced
P^* = the composite price for the two products and is a function of the price of broilers, P_B, and the price of litter, P_L

71

$C(Y_B)$ = variable cost of producing both Y_B and Y_L expressed in terms of Y_B

FC = fixed cost

π = profit (more appropriately as net returns to management; see [1] for detailed description of costs) per kg of bird (note that π is a function of both Y_B and Y_L even though it is expressed in terms of Y_B for simplicity).

Profit per bird will vary as the price of litter (P_L) changes. Profit was estimated on the basis of the following assumptions with respect to P_L: (1) the broiler producer has no alternative use for Y_L and gives it away, in which case P_L would be equal to zero; (2) Y_L is used as a substitute for corn silage, and P_L = 1.84¢/kg; and (3) Y_L is used at the margin as a substitute for protein supplement and P_L = 6.72¢/kg.[4]

Profit per bird was estimated to be 7.15¢, 9.84¢, and 16.98¢, respectively, for P_L = 0,

1.84¢/kg, and 6.72¢/kg.[5] Thus profit per bird increased substantially as P_L was increased; i.e., as litter moved to a higher and better use.

SUMMARY

Results of this study show that broiler litter is an economic alternative feed for beef steers. Its use as a feed in beef rations was estimated by both a production function approach and by least-cost rations. Ration composition from the production function approach was estimated to be: corn silage 24 percent, broiler litter silage 46 percent, and corn 30 percent on a dry matter basis.

Feed costs for beef steers can be reduced by using broiler litter. In addition, the use of litter as a feed has important revenue implications to poultry producers. Profit per bird increased from 7.15¢ with litter being given away to 9.84¢ with litter priced as a corn silage substitute.

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[4]Price estimates for BLS when used as a corn silage and protein concentrate substitute were derived from the least-cost rations.

[5]Profit per bird, π = 51.04¢ (Y_B) + P_L (.855) − 46.86¢ (Y_B) assuming a 1.71-kg bird is produced [1].