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ECONOMIC IMPACT OF RESTRICTIONS ON USE OF FEED ADDITIVES IN THE POULTRY INDUSTRY

William L. Henson

Department of Agricultural Economics and Rural Sociology
Agricultural Experiment Station
The Pennsylvania State University
University Park, Pennsylvania 16802

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Economics Statistics and Cooperative Service
United States Department of Agriculture

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Abstract

The possible economic impacts of proposed restrictions on the subtherapeutic level use of penicillin and tetracyclines and a proposed ban on use of nitrofurans in poultry rations were estimated for layers, broilers and turkeys. The 1976 production year was used as the base period. Changes in output levels and production costs associated with changes in production performance accompanying the restrictions were estimated. Two scenarios were evaluated: one in which it was assumed that the breeder flock size was held constant and final output was reduced and one in which there was a buildup in the breeder flock size and the level of final output remained the same.

The results indicate that each of the proposed restrictions would result in higher costs per unit of poultry produced and probably less total output. If previous base period output levels were continued after the restrictions were imposed, average production costs could increase as much as 1.5 cents per dozen for eggs, 2.0 cents per pound RTC for broiler meat and 1.5 cents per pound RTC for turkey meat. Total costs of U.S. poultry production could increase as much as $281.5 million. If previous base period breeding flock sizes were maintained, poultry industry output could decrease as much as 350 million dozens of eggs, 1.1 billion pounds RTC broiler meat and 174 million pounds RTC turkey meat. Total production costs, however, could also decrease as much as $269.1 million.

Economic Impact of Restrictions on Use of Feed Additives in the Poultry Industry

William L. Henson*

Introduction

Animal and poultry rations have been supplemented with feed additives for about 25 years. These additives have been credited with reductions in morbidity and mortality and improvements in growth rates and feed efficiency. The exact nature of the process from which these benefits are derived has not been completely determined. It varies among species, strains, types and dosages of additives, environmental conditions, animal health conditions, management techniques and other conditions of production.

Penicillin, tetracyclines and nitrofurans are three types of agents often added to poultry rations. In the tetracycline group, chlortetracycline and oxytetracycline are the most commonly used. NF-180, furazolidone, is the most commonly used agent among the nitrofurans. This study includes estimates of the impacts of proposed restrictions on subtherepeutic level additions of penicillin, chlortetracycline and oxytetracycline to poultry rations. Estimates of the possible impact of a proposed complete ban on the addition of nitrofurans are also presented. The major effects of these restrictions would be increased feed conversion rates and changes in the level of

*Agricultural Economist, N.E.D., E.S.C.S., U.S.D.A. stationed at University Park, Pennsylvania 16802.

inputs used in the production process which will affect costs per unit of output. Since some feed additives have a disease suppression function, changes in mortality and morbidity rates would also be expected.

Subtherapeutic uses of some animal drugs, including penicillan and tetracyclines, are being questioned by legislative authorities. (56) There is evidence that their use in animal feed may be linked to development of drug resistant strains of certain organisms which could make use of these drugs for treatment of human health problems less effective. Proposals to restrict the use of nitrofurans result from findings that these agents produce tumors in laboratory animals. The possibility of residue in human foods raises questions whether their use in animal feeds poses a human health threat. The U.S. Senate Committee on Agriculture, Nutrition and Forestry requested analysis of the economic consequences of certain proposed and potential restrictions on animal drug use. The U.S. Department of Agriculture conducted an analysis including estimates of impacts of the restrictions on all major meat and poultry subsectors. (56) This is a report on the development of the estimates of initial impacts of the restrictions on the poultry subsectors.

Procedure

Supplementation of poultry rations with one or more feed additives at various stages of production is a routine practice for many producers. There are others who feed supplemented rations periodically in response to temporary conditions such as health or performance of an individual flock or diagnosis of a disease prevalent in the area. The exact frequencies or levels of use associated with specific additives, species and stages of production are not generally available. The availability of data on the effectiveness of some of these drugs in field use is also limited.

In this study, tetracyclines refer to chlortetracycline and oxytetracycline only. In all instances restrictions on feed supplementation with penicillin or tetracyclines were assumed to be associated with use at subtherapeutic levels. Restrictions on supplementation with nitrofurans were assumed to be associated with all levels of use. Possible modifications of impacts because of interactions of effects among additives or substitutability among additives or between additives and changes in management practices could not be accounted for due to data limitations.

Economic impacts of the proposed restrictions were estimated for three poultry subsectors: eggs, broilers and turkeys. The 1976 production period was used as the base production period. The methodology used in the study included:

1. Estimation of the proportions of birds which in the base period received rations supplemented with additives included in the proposed restrictions.

2. Estimation of changes in production performance associated with use of additives included in the proposed restrictions among birds which received rations supplemented with these additives in the base production period.

3. Description of output levels, production costs and production performances of all poultry flocks during the base production period.

4. Estimation of output levels, production costs and production performances of all poultry flocks which would have been expected if the proposed restrictions had been in force in the base production period. Estimates were made for two possible industry reactions to the restrictions: a) no change in breeder flock sizes and a decrease in final output and b) an increase in breeder flock sizes and flock replacement rates so that the level of final output was constant.

5. Comparisons of output levels, production costs and production performance described in step 3 with those estimated in step 4.

Proportions of Poultry Receiving Feed Additives

Data on proportions of the poultry flock receiving specific feed additives were obtained from a private research firm (19) and a survey of poultry scientists. Data from the private research firm are not available for publication in raw form. The survey of poultry scientists included personal interviews of researchers in the Agricultural Research Service, U.S. Department of Agriculture, and personal and telephone interviews with other researchers and extension specialists at several state Agricultural Experiment Stations. Results of the survey of poultry scientists are summarized in Appendix Tables A-1 through A-7.

Based on data from these sources, representative estimates of percentages of birds receiving rations supplemented with additives included in the proposed restrictions were selected for use in the study. In the selection process, the heaviest weight was given to data supplied by the private research firm since there were results of field surveys specifically designed to collect the desired information. Substantial weight was also given where there was a consensus among poultry scientists. Where these criteria did not provide a basis for selection of an estimate, most weight was given to data supplied by scientists who were associated with major production areas for the relevant species or subsector.

Performance Response to Feed Additives

Flock performance rates which were assumed to be affected by the proposed restrictions were:

1. Mortality rates
2. Egg production per breeder or layer
3. Reproductivity (hatchability/fertility)
4. Chick or poult grow-out rates
5. Feed conversion rates
6. Condemnation rates

The responsiveness of poultry production performance to use of additives in feed rations varies among farms and among flocks on a given farm. In this study, average response rates were estimated for all farms on which each additive group was fed.

The initial source of data was a review of literature from the Poultry Science Journal. Rates of response to use of various feed additives in poultry rations have been subjects of many research studies. However, a large proportion of these studies was completed over twenty years ago. The validity of using results of these earlier studies to estimate current performance response is subject to question since many poultry production conditions have changed. In the review of literature, emphasis was placed on reports published since 1960. Caution is also warranted if a group of results of scientific research is used as a basis for estimating response rates under field conditions. Most research is conducted in controlled environments with regulated disease exposure and relatively small numbers of birds.

Sources of stress on the birds are also generally controlled under experimental conditions. Commercial poultry production, however, is usually conducted under high density, large flock conditions. Limiting disease exposure is sometimes difficult if not impossible. Certain sources of stress, such as changes in weather, are often beyond the poultry producer's control. The results of the review of literature, summarized in the Appendix, were used only as guidelines and as supplements to data collected in the survey of poultry scientists mentioned above.

Results of the survey of poultry scientists provided the primary source of data on performance responses used in this study. In the survey, the respondents were appraised of the proposed restrictions. Estimates, by species, of percentages of improvement in certain production performances associated with each additive group among those birds which received supplemented rations during the base production period were requested. The respondents were instructed to assume:

1. The effects of each additive group were independent.
2. No substitutes for the additives were available.

The results of the survey are summarized in Appendix Tables A-1 through A-7.

All survey respondents provided ranges of estimates of responses of production performances to use of feed additives. It was concluded, based on follow-up contacts with the survey participants, that evaluation of two possible impact levels would be more appropriate than evaluation of impacts based on the averages or mid-points of the ranges. In this study, a moderate response scenario was evaluted based on estimates in the lower parts of the ranges and a high response scenario was evaluated based on estimates in the upper parts of the ranges. The response rates used in the study represent those most frequently estimated by the poultry scientists. Data from the review of literature were used as a basis of evaluation of survey results. Where differences in data from the two sources could not be accounted for by experimental procedures, follow-up contacts with survey respondents and other poultry scientists were used to increase the level of confidence in the accuracy of the estimates.

It should be noted that nitrofurans when fed to layers presented a special case. It is illegal to feed nitrofurans to hens producing eggs for shell egg consumption. Also, some respondents reported that the use of nitrofurans in rations fed to laying flocks could be accompanied by decreases in egg production per bird. Supplementation of breeder rations with nitrofurans, however, may yet be justified on the basis of other performance improvements such as reduced mortality. This "insurance" function may be of particular importance to managers of breeding flocks whose individual birds may have higher values than those of managers of table egg or meat turkey flocks. This special case was accounted for by allowing the ban on use of nitrofurans to be accompanied by possible increases in rate of lay of breeding flocks in one scenario.

Sub-Sector Output and Performance: Base Year

Certain descriptive data for the base period were available in published statistical reports. (54, 56, 57) Hatching and bird placement data were lagged to account for time intervals between setting eggs and chick or poult placement and between bird placement and availability of output for marketing. Data from statistical reports included:

1. Egg Subsector
   - A. Number of eggs used for hatching, July, 1975 through June, 1976.
   - B. Number of egg type chicks hatched, August, 1975 through July, 1976.
   - C. Number of eggs produced per layer, 1976.
   - D. Number of layers on hand first of each month and annual average, 1976.
   - E. Total number of eggs produced, 1976.
   - F. Mature chickens slaughtered, 1976, total number and average liveweight.
   - G. Condemantion rates for mature chickens slaughtered, 1976.
   - H. Ready-to-cook weight of mature chickens certified, 1976.
2. Broiler Subsector
   - A. Number of broiler type chicks hatched, November, 1975, through October, 1976.
   - B. Number and average live weight of broiler chickens slaughtered under Federal Inspection, 1976.
   - C. Condemnation rates for broiler chickens slaughtered, 1976.
   - D. Ready-to-cook weight of broiler meat certified, 1976.
   - E. Broiler breeders slaughtered, 1976, total number.
3. Turkey Subsector
   - A. Number of poults hatched, August, 1975 through June, 1976.
   - B. Number and average liveweight of turkeys slaughtered under Federal inspection, 1976.
   - C. Condemnation rates for turkeys slaughtered, 1976.
   - D. Ready-to-cook weight of turkey meat certified, 1976.

Initial estimates of base flock performance rates were calculated by using data from a poultry management manual (15), several other recent publications on industry performance (4, 24, 33, 55) and unpublished results of recent industry surveys. Published standards of performance for poultry production, however, are often target rates rather than those observed in the field. Differences also often occur between published statistical series and expected performance rates. In broiler production, for example, based on data in published statistical series for November, 1975 through December 1976, estimated growout mortality was 5.29 percent of the number of chicks housed. Expected mortality based on a recent publication in which industry performance was described was 3 to 5 percent. (4) Broiler mortality on a group of farms included in a recent survey was about 2 percent. Several reasons for the differences are possible. The proportion of broilers slaughtered outside of Federal inspection, though it is relatively small, is not accounted for in aggregate statistics. Basic target standards for and performance of individual operations differ from industry performance since overall industry losses include catastrophic losses such as entire flocks. Also, statistics on birds slaughtered may be more accurate than those on chicks housed.

In this study, where feasible, base performance rates were calculated from data in statistical reports. An adjustment was made if, in the author's opinion, the difference between published standards and a calculated performance was too large to be explained.

1. Egg production subsector

It was assumed that production per egg type breeding hen was 235 eggs, mortality for the production period was 22.0 percent of the average number of breeders on hand and the number of chicks hatched was 82.8 percent of the number of eggs used for hatching. It was also assumed that 70.0 percent of the eggs produced by breeding hens were used for hatching while 30.0 percent were sold for other uses. These assumptions provided the basis for calculation of the number of eggs used for hatching and the number of breeders needed to produce those eggs. The number of egg-type hens slaughtered was calculated by subtracting the number of broiler breeders slaughtered from the total number of mature chickens slaughtered. The egg type breeding flock was 1.5 percent of the total egg type laying flock thus the number of egg type breeders slaughtered was assumed to be 1.5 percent of the total number of egg type mature chickens slaughtered. Given the rates of breeder mortality and slaughter, a breeder replacement rate was calculated to maintain the required breeder flock size. The number of egg type pullet chicks hatched was assumed to be 50 percent of the egg type chicks hatched. It was also assumed that pullet growout mortality was 6.0 percent of chicks housed and 90.0 percent of the pullets raised to five months old were housed as breeder or layer replacements. The culls were salvaged as meat, however no value for salvage was entered in the calculations. The number of pullets housed for layer replacements was calculated by subtracting the number of pullets housed for breeder replacements from the total number of pullets housed. Layer house mortality for the production period was assumed to be 16.1 percent of the average number of layers on hand. Calculation of the number of layers slaughtered was explained above. Total flock depletion was not accounted for by slaughter and the estimated rate of mortality. The difference was accounted for as "Other Losses" to avoid exageration of the mortality rate. The number of eggs produced for shell egg use was calculated by subtracting the number of eggs used for hatching from the total number of eggs produced. Egg production per layer was calculated by dividing the number of eggs produced by the average number of layers on hand producing eggs for shell egg use. Average live weight of spent layers and breeders slaughtered was assumed to be 4.37 pounds per bird, the average live weight of mature chickens inspected during 1976. The yield of ready-to-cook chicken was calculated by dividing the number of ready-to-cook pounds of mature chicken certified wholesome in 1976 by the number of net pounds liveweight inspected. Net pounds liveweight inspected was calculated by subtracting slaughtering plant condemantions from total pounds liveweight inspected. The ready-to-cook yield for both breeders and spent layers was 65.9 percent of net pounds liveweight inspected.

2. Broiler production subsector

It was assumed that annual production per meat type breeding hen was 150 eggs, annual mortality was 17.5 percent of the average number of breeders on hand and the number of chicks hatched was 81.8 percent of the number of eggs used for hatching. It was also assumed that 90.0 percent of the number of eggs produced by breeding hens were used for hatching while 10.0 percent were sold in the shell egg market. These assumptions provided the basis for calculation of the number of breeding hens needed. A broiler breeder hen replacement rate was calculated to maintain the required breeder hen flock size. Mortality among breeder replacements was assumed to be 6.0 percent of the number of chicks housed and 90.0 percent of replacements grown out were assumed to be housed as replacement hens. The number of breeder replacement chicks was subtracted from the total number of meat type chicks hatched and the remainder was the estimate of the number of broiler chicks housed.* The mortality rate was calculated by dividing the number of

*The number of chicks hatched for broiler breeder replacements is actually included in the egg type chick hatch total. This was not noted in the data report used.

young chickens inspected by the number of broiler chicks housed. The percentages yield of liveweight inspected for broilers and broiler breeders were calculated by use of the procedure described for calculation of yield from spent egg layers slaughtered. Ready-to-cook yieldswere 65.9 and 73.8 percent for broiler breeders and young chickens respectively.

3. Turkey production subsector

There were fewer statistical series available for the turkey subsector than for the egg and broiler subsectors. It was necessary to rely more heavily on information obtained from the poultry scientists and data from descriptive publications to provide a foundation for description of base period output in the turkey subsector. To accomodate use of those statistical series available, turkey production data were calculated separately for light and heavy breeds. Also, slaughter data were calculated separately for fryer/roasters and young/old turkeys. Fryer/roaster slaughter data were combined in statistical reports. Young and old turkeys were combined in this study since old turkeys usually represent less than 1.0 percent of total turkey production. It was assumed that annual turkey breeder mortality was 15.0 percent of the average number of breeders on hand, annual production was 160.0 eggs per breeding hen and 90.0 percent of the eggs produced were used for hatching. It was also assumed that the numbers of poults hatched were 67.3 and 71.9 percent of the numbers of eggs set for light and heavy breeds respectively. Given these assumptions and reported numbers of poults hatched, the size of breeder stock and breeder flock replacement and depletion rates were estimated. The growout mortality rate among breeder replacements was assumed to be 6.0 percent of the number of poults housed. It was also assumed poults housed for breeder replacement could readily be sold as meat birds after growout thus no allowance was made for housing less than 100.0 percent of replacements grown out. Among turkeys placed for meat, the growout period was separated into two intervals, the first 8 weeks and 8 weeks-to-market age. This was to account for differences in response to feed additives between young poults and older turkeys. It was also to account for differences in age and weight at marketing between light and heavy breeds. During the first 8 weeks of turkey growout, the mortality rate was assumed to be 4.0 percent of the number of poults housed. Liveweights at 8 weeks old were assumed to be 4.0 and 5.0 pounds per bird for light breeds and heavy breeds respectively. Mortality rates among birds 8 weeks old to market age were assumed to be 3.5 and 6.6 percent of the numbers of 8 week old light breed and heavy breed turkeys respectively. Weight gains from 8 weeks old to market age were 5.2 and 14.3 pounds per bird for light and heavy breeds respectively. Liveweight of breeders slaughtered was assumed to be 19.3 pounds per bird for all breeders slaughtered. The calculated ready-to-cook yield was 81.3 percent of net live weight pounds inspected for all turkeys slaughtered. Net pounds inspected was defined under discussion of the egg subsector.

Subsector Output and Performance Under the Proposed Restrictions

It was assumed that supplementation of poultry rations with feed additives resulted in changes in production performance among only those birds which received supplmented rations. The changes were assumed to result in average production performance rates among affected birds equal to those among all other birds.

By subsector and additive group, data on performance response to feed additives and base period performance rates were used to calculate performance rates expected among affected birds if the proposed restrictions had been in force during the base production period. For example, among poults up to 8 weeks old, it was estimated that the use of nitrofurans in feed rations, high response, was associated with 60.0 percent decrease in percentage mortality among those poults fed supplemented rations. The base production period mortality rate for all poults was 4.0 percent of the number of day old poults housed. If the proposed restrictions on use of nitrofurans had been in force, based on the high response estimate of the efficacy of nitrofurans, expected mortality among affected poults would be 10.0 percent of day old poults housed. This was calculated as follows:

$$M_1 = M_2 + b\ M_2$$

where M_1 = average mortality rate for poults up to 8 weeks old during the base production period (4.0%) expressed as a fraction (.04).

M_2 = expected average mortality rate for affected poults up to 8 weeks old if the ban on use of nitrofurans had been in force expressed as a fraction.

b = percentage change in M_2 associated with use of nitrofurans in poult rations, high response (-60.0%) expressed as a fraction (-.60).

therefore $.04 = M_2 + (-.60\ M_2)$

$$.04 = .40\ M_2$$

$$M_2 = .10$$

Industry average expected performance rates, assuming the proposed restrictions had been in force were calculated as weighted averages of rates for unaffected birds and those expected for affected birds. Continuing with the example above, it was estimated that 90.0 percent of all poults up to 8 weeks old received rations supplemented with nitrofurans. Thus 90.0 percent of all poults would be affected birds and 10.0 percent would be unaffected. If the proposed restrictions on use of nitrofurans in poultry rations had been in force the expected industry average mortality rate among poults up to 8 weeks old would have been:

$$M_3 = P_1M_1 + P_2M_2$$

where M_3 = industry average expected mortality rate among poults up to 8 weeks old if the ban on use of nitrofurans had been in force expressed as a fraction.

P_1 = percentage of all poults up to 8 weeks old which did not receive rations supplemented with nitrofurans during the base production period (10.0%) expressed as a fraction (.10).

P_2 = percentage of all poults up to 8 weeks old which did receive rations supplemented with nitrofurans during the base production period (90.0%) expressed as a fraction (.90).

M_1 and M_2 = defined above,

therefore $M_3 = (.10 \times .04) + (.90 \times .10) = .0940$

It was assumed that the proposed restrictions were in force during the base production period. For each subsector and additive group, industry average expected performance rates with the proposed restrictions in force were substituted for those used to describe output and performance in the base production period.

Assuming the rate of breeder flock replacement in each subsector did not change from that in the base production period, expected changes in levels of final output associated with the proposed restrictions were calculated. In another scenario considered, it was assumed the imposition of the proposed restrictions was accompanied by changes in sizes of breeder flocks and replacement rates to maintain base period final output levels. Estimates of changes in flock sizes required because of the differences in performance rates were calculated. In both instances, changes were calculated based on both the moderate and high response estimates of effects of each feed additive group on production performance.

Feed Use and Costs of Production

Estimates of feed conversion rates for the base production period were included in the data collected in the survey of poultry scientists. These data, supplemented with data from a poultry management manual (15) and other publications on industry performance (4, 24, 33, 54) were used with base production period output levels to estimate quantities of feed used in each subsector of the poultry industry. Changes in feed conversion rates associated with the proposed restrictions were calculated for each additive group and production subsector. Industry average expected feed conversion rates, assuming the proposed restrictions had been in force, were calculated using the same methodology used for other production performance rates. These expected feed conversion rates were used with expected output levels associated with the proposed restrictions and changes in total feed use and feed use per unit of output were estimated for each additive group and production subsector.

Production costs were also calculated for each production subsector for the base production period based on data from the same sources supplemented with unpublished data collected in recent industry surveys. It was assumed that imposition of the proposed restrictions would effect feed costs only. There would be little, if any change in total industry costs of inputs other than feed, for example housing, equipment and labor costs. This is particularly true in production periods closely following imposition of the proposed restrictions. It was also assumed that feed prices would not change because of imposition of the proposed restrictions. Additive cost is usually a minor ingredient cost. Furthermore, those birds fed rations supplemented with additives usually did not receive additives in all of their feed. Changes in total costs and cost per unit of output associated with each proposed restriction and production subsector were calculated and compared with costs estimated for the base production period.

Subsector Changes Associated with the Proposed Restrictions

Egg Production Subsector

Percentages of birds in the egg production subsector which were estimated in this study to have received rations in the base period supplemented with additive groups included in the proposed restrictions are reported in Tables 1, 2 and 3. Data are reported for breeders in Table 1, replacement pullets in Table 2 and table egg laying hens in Table 3. Table egg laying hens include all laying hens except breeders. The tables also include estimated percentages of improvement in base

Table 1. Frequency of Use and Rates of Response to Use of Selected Feed Additives and Production Performance, 1976: Chickens, Breeders, 5 Month Old and Older, Egg and Meat Type.

	Additives					
	Penicillin		Tetracyclines		Nitrofurans	
Percentage of birds using	10		40		20	
	Response Level					
	Moderate	High	Moderate	High	Moderate	High
	Percentage Improvement					
Effect on birds using:						
Reproductive performance	3	10	5	10	-3	10
Feed efficiency	4	8	4	8	-1	3
Mortality	2	5	2	7	1	2
Condemnations	1	2	1	2	1	2

Base performance rates

1) Reproductive performance = % eggs produced per hen used for hatching times egg produced per hen times fertility, hatchability percentage.
   Egg type breeders = (.70 x 235.0 x .828) = 136.2
   Meat type breeders = (.90 x 150.0 x .818) = 110.4
2) Feed efficiency: Broiler breeders: 42.4 tons per mo. per 9,100 breeders on hand.
   Egg type breeders: 32.2 tons per mo. per 10,000 average layers on hand.
3) Mortality = % average breeders on hand.
   Egg type breeders = 22.00%; Meat type breeders = 17.52%
4) Condemnations: Ante mortem = .94% of lbs. inspected live weight.
   Post mortem = 4.22% of lbs. inspected live weight.

Table 2. Frequency of Use and Rates of Response to Use of Selected Feed Additives and Production Performance, 1976: Replacement Chicken Growout, Egg Type, 0-5 Months Old.

	Additives					
	Penicillin		Tetracyclines		Nitrofurans	
Percentage of birds using	20		30		20	
	Response Level					
	Moderate	High	Moderate	High	Moderate	High
	Percentage Improvement					
Effect on birds using:						
Feed efficiency	3	6	4	8	2	5
Mortality	8	12	10	15	2-	30

Base performance rates

1) Feed efficiency: Broiler breeders: 156.5 tons feed per 9,100 replacement pullets.
Egg type breeders: 94.0 tons feed per 10,000 replacement pullets.
Egg layer: 83.0 tons feed per 10,000 replacement pullets.

2) Mortality: 6.0% of chicks started.

Table 3. Frequency of Use and Rates of Response to Use of Selected Feed Additives and Production Performance, 1976: Table Egg Laying Hens, 5 Months Old and Older.

	Additives					
	Penicillin		Tetracyclines		Nitrofurans	
Percentage of birds using	10		20		illegal	
	Response Level					
	Moderate	High	Moderate	High	Moderate	High
	Percentage Improvement					
Effect on birds using:						
Egg production	5	10	5	10	-	-
Feed efficiency	4	8	4	8	-	-
Mortality	2	5	2	7	-	-
Condemnations	1	2	1	2	-	-

Base performance rates
1) Egg production: 246.6 eggs per layer on hand per year.
2) Feed efficiency: 4.3 lbs. feed per dozen eggs produced = 88.4 lbs. feed per year per average layer on hand.
3) Mortality = 16.08% of average layers on hand.
4) Condemnations: Ante mortem = .94% of lbs. liveweight inspected.
   Post mortem = 4.22% of liveweight pounds inspected.

performance rates associated with use of each additive group.

The tetracycline additive group was the one most frequently used in the egg production subsector at each stage of production. Among mature birds, this additive group's largest impact was on reproductive performance which includes rate of lay, hatchability and fertility. Its impact on feed efficiency is a reflection of the impact on rate of lay. Among replacement pullets, nitrofurans were used less frequently than tetracyclines however, when used they were more effective in reducing mortality rates. Nitrofurans were not fed to table egg layers, however, in the moderate response scenario, when they were fed to breeding hens their use was associated with decreases in productive performance and feed efficiency. Effects of all additive groups on condemnation rates were minimal for both spent layers and breeders.

Base production period output data for the egg subsector are summarized in Table 4. Row labels of production performance rates are indented for identification. Table 4 also includes estimates of expected output and performance of the subsector if the proposed restrictions on use of tetracyclines in poultry rations had been in force. Expected output and performance were calculated based on high efficiency estimates of response to use of tetracyclines. This detailed table is presented as an aid in interpretation of data included in other tables. Base period data in Table 4 would be the same in Tables 5 and 6 and will not be repeated. Nor will most data assumed to have remained the same when the restrictions were imposed be repeated in Table 5 and 6. These data include initial breeding

Table 4. Effect of Banning Sub-therapeutic Level Feeding of Tetracyclines in Poultry Rations on U.S. Annual Egg Output, High Response.

	1976 Base Data	Tetracyclines Restricted: Base Breeder Maintained Replacement	Tetracyclines Restricted: Base Output Maintained
Egg type breeder hens 1st of month (mill.)	3.44	3.44	3.44
Breeder hen replacements (mill.)	2.92	2.92	3.43
Breeder hen slaughter (mill.)	2.16	2.16	2.16
Mortality (% ave. breeders)	22.06	22.67	22.67
Breeder Mortality (mill.)	.76	.78	.87
Average breeder hens on hand (mill.)	3.44	3.42	3.84
Eggs per breeder (no.)	235.0	226.5	226.5
Eggs set (mill.)	565.9	542.2	608.8
Hatchability, fertility (% eggs set)	82.80	79.80	79.80
Pullets hatched	234.3	216.7	242.9
Grow-out mortality (% pullets hatched)	6.00	6.32	6.32
Egg layers on hand 1st of month (mill.)	239.2	239.2	239.2
Replacement hens housed (mill.)	195.3	179.8	201.1
Spent layers slaughtered (mill.)	148.8	148.8	148.8
Mortality (% ave. layers)	16.08	16.32	16.32
Layer Mortality (mill.)	38.46	36.79	39.77
Other losses (mill.)	8.04	8.04	8.04
Average layers on hand (mill.)	239.2	225.4	243.7
Eggs per layers (no.)	246.6	242.1	242.1
Eggs produced (mill. excl. breeders)	58,998.6	54,569.3	58,998.6
Percentage change from base		-7.51	
Egg type hatching eggs sold (mill.)	242.5	232.4	261.0
Broiler type hatching eggs sold (mill.)	471.8	452.9	514.8
Total eggs available (mill.)	59,712.9	55,254.6	59,774.4
Percentage change from base		-7.47	
Lbs. breeders inspected (mill. liveweight)	9.44	9.44	9.44
Ante mortem condemn. (%)	.94	.95	.95
Post mortem condemn. (%)	4.22	4.25	4.25
Lbs. spent layers inspected (mill. liveweight)	650.3	650.3	650.3
Ante mortem condemn. (%)	.94	.94	.94
Post mortem condemn. (%)	4.22	4.23	4.23
R.T.C. lbs. certified (mill.)	412.3	412.3	412.3

stocks, numbers of spent layers and breeders slaughtered and layer flock depletion other than slaughter and mortality.

Tables 5 and 6 include summaries of expected output and industry average performance rates associated with the proposed restrictions for the egg production subsector. The data in Table 5 were calculated assuming breeder replacements rates under the proposed restrictions were the same as those in the base production period. The effects of changes in production performance rates are reflected in changes in final output levels. The data in Table 6 were calculated assuming imposition of the restrictions was accompanied by changes in breeder and layer flock replacement rates and the number of layers on farms so that the level of final output in the base production period was maintained.

Based on the data in Tables 5 and 6 also, the proposed restrictions on use of tetracyclines in poultry rations would have the greatest impact on the egg production subsector. Under this restriction, with no increase in the number of layers on farms, egg production excluding hatching eggs, decreased as much as 7.51 percent. To maintain base period output, the size of the breeding flock was required to increase as much as 11.63 percent though the size of the laying flock was only required to increase by 1.88 percent. Though the restriction on use of tetracyclines was accompanied by negative impacts on all production performance rates, the relatively large increase in breeding flock size was required mostly to offset the increase in mortality rates during replacement pullet growout. The ban on nitrofurans had the least

Table 5. Performance Coefficients and U.S. Egg Production Levels Associated with Proposed Restrictions on Use of Feed Additives in Poultry Rations, 1976 Breeder Replacement Rates.

	Ban at Sub-therapeutic Levels				Ban on Nitrofurans	
	Penicillin		Tetracyclines			
	Moderate Response	High Response	Moderate Response	High Response	Moderate Response	High Response
Breeder replacements (mill.)	2.92	2.92	2.92	2.92	2.92	2.92
Mortality (% ave. breeders)	22.04	22.12	22.18	22.67	22.04	22.09
Ave. no. breeders on hand (mill.)	3.44	3.44	3.44	3.42	3.44	3.44
Eggs per breeder (no.)	233.9	232.9	230.5	226.5	236.5	230.7
Hatchability, fertility (%)	82.40	82.00	81.20	79.80	83.30	81.30
Pullets hatched (mill.)	232.0	229.9	225.3	216.7	237.2	225.8
Growout mortality (%)	6.10	6.16	6.20	6.32	6.30	6.51
Ave. Layers 1st of Month (mill.)	239.2	239.2	239.2	239.2	239.2	239.2
Pullets added (mill.)	193.1	191.2	187.3	179.8	197.1	187.1
Mortality (% ave. layers)	16.08	16.20	16.20	16.32	16.08	16.08
Ave. no. layers on hand (mill.)	237.3	235.4	232.1	225.4	240.7	232.1
Eggs per layer (no.)	245.4	244.4	244.3	242.1	246.6	246.6
Eggs produced (mill. excl. hatching)	58,233	57,532	56,702	54,569	59,357	57,236
Percentage change	-1.30	-2.49	-3.89	-7.51	+.61	-2.58
Eggs available (mill.)						
Incl. egg type hatching sales	58,475	57,772	56,940	54,802	59,601	57,474
Incl. egg and broiler hatching sales	58,944	58,239	57,403	55,255	60,075	57,937
Percentage change	-1.29	-2.47	-3.87	-7.47	+.61	-2.97
R.T.C. lbs. spent layers and breeders certified (mill.)	412.3	412.3	412.3	412.3	412.3	412.3

Table 6. Performance Coefficients and Flock Replacement Rates for the U.S. Egg Production Subsector Associated with Proposed Restrictions on Use of Feed Additives in Poultry Rations, 1976 Egg Production Rates.

	Ban at Sub-therapeutic Levels				Ban on	
	Penicillin		Tetracyclines		Nitrofurans	
	Moderate Response	High Response	Moderate Response	High Response	Moderate Response	High Response
Breeder replacements (mill.)	2.99	3.07	3.17	3.43	2.88	3.11
Percentage change	+2.40	+5.14	+8.56	+17.47	-1.37	+6.51
Mortality (% ave. breeders)	22.04	22.12	22.18	22.67	22.04	22.09
Ave. no. breeders on hand (mill.)	3.50	3.56	3.64	3.84	3.41	3.60
Percentage change	+1.74	+3.49	+5.81	+11.63	-.87	+4.65
Eggs per breeder (no.)	233.9	232.9	230.5	226.5	236.5	230.7
Hatchability, fertility (%)	82.40	82.00	81.20	79.80	83.30	81.30
Pullets hatched (mill.)	236.0	238.1	238.6	242.9	235.0	236.0
Growout mortality (%)	6.10	6.16	6.20	6.32	6.30	6.51
Ave. Layers 1st of Month (mill.)	239.2	239.2	239.2	239.2	239.2	239.2
Pullets added (mill.)	196.7	197.8	198.2	201.1	195.3	195.3
Percentage change	+.72	+1.28	+1.48	+2.97	.00	.00
Mortality (% ave. layers)	16.08	16.20	16.20	16.32	16.08	16.08
Ave. no. layers on hand (mill.)	240.4	241.1	241.5	243.7	239.2	239.2
Percentage change	+.50	+.79	+.96	+1.88	.00	.00
Eggs per layer (no.)	245.4	244.4	244.3	242.1	246.6	246.6
Eggs produced (mill. excl. hatching)	58,999	58,999	58,999	58,999	58,999	58,999
Eggs available (mill.)						
Incl. egg type hatching sales	59,244	59,247	59,250	59,260	59,241	59,248
Incl. egg and broiler type hatching sales	59,724	59,732	59,743	59,774	59,714	59,739

impact on the egg production subsector though it had the greatest effect on mortality rates during pullet growout. This was because nitrofurans were not fed to the laying flock and the impact of their use on breeder flock performance was relatively low. In fact, since the ban on use of nitrofurans based on moderate response estimates was accompanied by increased industry average reproductive performance, in that scenario the final output level actually increased at base production period replacement rates. Conversely, the base period output level could be maintained with a slightly lower rate of breeder flock replacements and number of layers on farms in this scenario.

Estimates of feed conversion rates and total feed use in the egg production subsector for the base production period and rates and use expected if the restrictions had been imposed are reported in Table 7. In most instances, at base period breeder replacement rates, the restrictions were accompanied by decreases in total feed used but increases in feed used per dozen eggs produced. Total feed used decreased 4.3 percent when use of tetracyclines was restricted and high efficiency estimates of production performance responses were used in the calculations. In the same scenario, however, feed used per dozen eggs increased 3.5 percent. Even in the scenario which included a ban on use of nitrofurans and moderate response estimates of production performance changes associated with use of feed additives, the increase in total feed used was greater than the increase in eggs produced. Feed used per dozen eggs increased about .2 percent.

Table 7. Annual Feed Use in the U.S. Egg Production Subsector Associated with Proposed Restrictions on Use of Feed Additives in Poultry Rations, 1976.

	1976 Base Data	Ban at Sub-therapeutic Levels: Penicillin, Moderate Response	Ban at Sub-therapeutic Levels: Penicillin, High Response	Ban at Sub-therapeutic Levels: Tetracyclines, Moderate Response	Ban at Sub-therapeutic Levels: Tetracyclines, High Response	Ban on Nitrofurans, Moderate Response	Ban on Nitrofurans, High Response
Pounds of feed per:							
Breeder replacement	18.8	18.9	19.0	19.0	19.3	18.9	19.0
Ave. breeder on hand	77.3	77.6	78.0	78.6	80.0	77.1	77.8
Layer flock replacement	16.6	16.7	16.8	16.8	17.0	16.7	16.8
Ave. layer on hand	88.4	88.8	89.2	89.1	89.9	88.4	88.4
	1976 Breeder Replacement Rate						
Mill. tons of feed for:							
Breeder replacement	.027	.029	.028	.028	.028	.028	.028
Breeders	.133	.133	.134	.135	.136	.133	.134
Layer replacement	1.621	1.612	1.606	1.573	1.528	1.646	1.572
Layers	10.572	10.535	10.499	10.340	10.132	10.639	10.259
Total	12.353	12.308	12.267	12.076	11.824	12.446	11.993
Percentage change		-.364	-.696	-2.242	-4.282	+.753	-2.914
Lbs. per doz. eggs*	5.004	5.052	5.055	5.090	5.178	5.012	5.008
Percentage change		+.959	+1.019	+1.719	+3.477	+.160	+.080
	1976 Egg Output Level						
Mill. tons of feed for:							
Breeder replacement	.027	.028	.029	.030	.033	.027	.030
Breeders	.133	.136	.139	.143	.154	.131	.140
Layer replacement	1.621	1.642	1.662	1.665	1.709	1.631	1.641
Layers	10.572	10.674	10.753	10.759	10.954	10,573	10.573
Total	12.353	12.480	12.583	12.597	12.850	12.362	12.384
Percentage change		+1.028	+1.862	+1.975	+4.023	+.073	+.251
Lbs. per doz. eggs*	5.004	5.056	5.097	5.103	5.204	5.008	5.016
Percentage change		+1.039	+1.859	+1.978	+3.997	+.080	+.240

* Includes egg type hatching eggs sold, excludes broiler type hatching eggs.

At base production period output levels, each of the restrictions was accompanied by increases in both total feed used and feed used per dozen eggs.

Table 8 includes estimates of egg production costs during the base production period and costs associated with the proposed restrictions. Again, the restriction on use of tetracyclines and use of the high response estimates of efficacy of feed additives were associated with the largest percentage increases in costs per dozen eggs produced. The least impact on costs per dozen eggs produced was associated with the ban on use of nitrofurans. Increases in costs per dozen eggs associated with the restrictions were less when base production period output levels were maintained than when base period breeder replacement rates were maintained. This was because when base period output levels were maintained, fixed costs were associated with a higher output level.

Broiler Production Subsector

Proportions of broilers fed rations supplemented with additives included in the proposed restrictions estimated in this study are summarized in Table 9. The table also includes estimates of responses of production performance rates to use of the additive groups among birds receiving supplemented rations and production performance rates for the base production period. Similar data for broiler breeders and breeder replacement pullet growout were included in Tables 1 and 2.

The tetracycline group was the one estimated to be most frequently used in broiler rations. Estimates of its effects on broiler growth rates and feed efficiency were also generally higher than those

Table 8. Annual U.S. Egg Production Subsector Costs Associated with Proposed Restrictions on Use of Feed Additives in Poultry Rations, 1976.

		1976 Base Data	Ban at Sub-therapeutic Levels: Penicillin, Moderate Response	Penicillin, High Response	Tetracyclines, Moderate Response	Tetracyclines, High Response	Ban on Nitrofurans: Moderate Response	Nitrofurans, High Response
Cost (mill. dollars)*			1976 Breeder Replacement Rates					
Breeders:	Feed	20.1	20.1	20.2	20.4	20.5	20.1	20.2
	Replacements	6.4	6.4	6.4	6.4	6.4	6.4	6.4
	Other	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Pullets:	Feed	259.4	257.9	257.0	251.7	244.5	263.4	251.5
	Chicks	30.3	30.3	30.4	30.6	30.7	30.3	30.4
	Other	121.3	121.3	121.3	121.3	121.3	121.3	121.3
Layers:	Feed	1596.4	1590.8	1585.3	1561.3	1529.0	1606.5	1549.1
	Replacements	411.0	409.5	408.7	403.6	396.5	415.0	403.2
	Other	162.7	162.7	162.7	162.7	162.7	162.7	162.7
Cost (cents per doz. eggs)**		44.0	44.4	44.8	44.8	45.7	44.0	44.2
Percentage change			+.91	+1.82	+1.82	+3.86	.00	+.45
			1976 Egg Output Level					
Breeders:	Feed	20.1	20.5	21.0	21.6	23.3	19.8	21.1
	Replacements	6.4	6.6	6.8	7.0	7.5	6.3	6.8
	Other	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Pullets:	Feed	259.4	262.7	265.9	266.4	273.4	261.0	262.6
	Chicks	30.3	30.9	31.6	32.4	34.6	29.9	31.7
	Other	121.3	121.3	121.3	121.3	121.3	121.3	121.3
Layers:	Feed	1596.4	1611.8	1623.7	1624.6	1654.1	1596.5	1596.5
	Replacements	411.0	414.9	418.8	420.1	429.3	412.2	415.6
	Other	162.7	162.7	162.7	162.7	162.7	162.7	162.7
Costs (cents per doz. eggs)**		44.0	44.3	44.7	44.7	45.5	44.0	44.0
Percentage change			+.68	+1.59	+1.59	+3.41	.00	.00

* Feed prices: Breeders and layers = $151.00 per ton (35), Pullet growout = $160.00 per ton (estimated). Breeder replacements @ $2.20 each (estimated).

**Includes egg type hatching eggs sold for non-hatching uses. Cost per dozen is total of layer costs divided by dozens of eggs produced.

Table 9. Frequency of Use and Rates of Response to Use of Selected Feed Additives and Base Production Performance Rates: Broiler Chickens, 0-8 Weeks Old.

	Additives					
	Penicillin		Tetracyclines		Nitrofurans	
Percentage of birds using	20		40		30	
	Response Level					
	Moderate	High	Moderate	High	Moderate	High
	Percentage Improvement					
Effect on birds using:						
Growth rate	5	10	6	12	2	5
Feed efficiency	4	7	6	12	2	5
Mortality	8	12	8	12	20	30
Condemnations	8	12	10	15	10	15

Base performance rates
1) Growth rate: 3.81 lbs. liveweight per bird at 8 weeks.
2) Feed efficiency: 2.10 lbs. of feed per pound of liveweight inspected.
3) Mortality: 5.29 percent of chicks housed.
4) Condemnations: Ante mortem = .33% of pounds inspected.
Post mortem = 1.56% of pounds liveweight inspected.

associated with the other additives. The use of nitrofurans was estimated to be associated with the largest improvements in mortality rates. This was probably because the proposed restriction on use of nitrofurans included therapeutic as well as sub-therapeutic dosages. The efficacy of use of tetracyclines and nitrofurans in improving condemnation rates was estimated at similar levels though use of penicillin was slightly less effective.

Table 10 includes base production period production performance and output data for broilers. Performance and output data expected if the proposed restrictions on use of tetracyclines had been in force are also included in the table. These data were calculated using high response estimates of the efficacy of tetracyclines. Changes associated with restrictions on use of tetracyclines are included in the detailed table because use of this additive group was estimated to exert the largest impact on the broiler subsector. It was assumed that imposition of the restrictions would not effect the initial breeder flock size or the rate of breeder slaughter thus estimates of these data reported in Table 10 will not be repeated in Tables 11 and 12. The number of broiler hatching eggs sold in each scenario can be determined from data in Tables 5 and 6. Percentage changes in output reported in Table 11 and in replacement rates reported in Table 12 are changes from base levels reported in Table 10.

The results reported in Table 11 were calculated based on the assumption that no change in base production period breeder replacement rates accompanied imposition of the restrictions. Under this assumption, it was estimated the proposed restrictions on use of tetracyclines

Table 10. Effect of Banning Sub-therapeutic Level Feeding of Tetracyclines in Poultry Rations on U.S. Annual Broiler Meat Output, High Response.

	1976 Base Output	Tetracyclines Restricted: Base Breeder Replacement Maintained	Tetracyclines Restricted: Base Output Maintained
Broiler type breeding hens			
1st of month (mill.)	31.6	31.6	31.6
Breeder hen replacements (mill.)	32.4	32.4	37.3
Breeder hen slaughter (mill.)	27.0	27.0	27.0
Mortality (% ave. breeders)	17.5	18.0	18.0
Average breeder hens on hand (mill.)	31.5	31.3	35.5
Eggs per breeder (no.)	150.0	144.6	144.6
Eggs set (mill.)	4,245.8	4,076.0	4,620.0
Hatchability, fertility (% eggs set)	81.8	78.8	79.8
Chicks hatched	3,743.0	3,211.9	3,640.8
Breeder chicks placed (mill.)	38.2	38.4	39.9
Growout mortality (%)	6.00	6.32	6.32
Broiler chick placements (mill.)	3,434.7	3,173.4	3,600.9
Growout mortality (%)	5.29	5.58	5.58
Young chickens inspected (mill.)	3,253.0	2,996.4	3,400.0
Ave. liveweight (lbs. each)	3.81	3.65	3.65
Broiler meat inspected (mill. lbs.)	12,394.0	10,936.7	12,410.0
Ante mortem condemn. (% lv.wt.)	.33	.35	.35
Post mortem condemn. (% lv.wt.)	1.56	1.67	1.67
R.T.C. lbs. certified (mill.)	8,973.6	7,908.3	8,973.6
Percentage change		-11.87	
Lbs. breeders inspected (mill. lv.wt.)	118.0	118.0	118.0
Ante mortem condemn. (% lv.wt.)	.94	.95	.95
Post mortem condemn. (% lv.wt.)	4.22	4.25	4.25
R.T.C. lbs. breeders certified (mill.)	73.7	73.7	73.7
Hatching eggs sold (mill.)	471.8	452.9	514.8

Table 11. Performance Coefficients and U.S. Broiler Meat Production Levels Associated with Proposed Restrictions on Use of Feed Additives in Poultry Rations, 1976 Breeder Replacement Rate.

	Ban at Sub-therapeutic Levels				Ban on	
	Penicillin		Tetracyclines		Nitrofurans	
	Moderate Response	High Response	Moderate Response	High Response	Moderate Response	High Response
Breeder replacements (mill.)	32.4	32.4	32.4	32.4	32.4	32.4
Mortality (% ave. breeders)	17.5	17.5	17.5	18.0	17.5	17.5
Ave. no. breeders on hand (mill.)	31.5	31.4	31.4	31.3	31.5	31.4
Eggs per breeder (no.)	149.3	148.6	147.2	144.6	150.9	147.3
Hatchability, fertility (%)	81.4	81.1	80.2	78.8	82.3	80.3
Chicks hatched (mill.)	3,439.9	3,410.1	3,340.5	3,211.9	3,515.2	3,346.9
Breeder chicks placed (mill.)	38.3	38.3	38.4	38.4	38.4	38.5
Growout mortality (%)	6.10	6.16	6.20	6.32	6.30	6.51
Broiler chick placements (mill.)	3,401.6	3,371.9	3,302.1	3,173.4	3,476.8	3,308.4
Growout mortality (%)	5.38	5.43	5.47	5.58	5.69	5.97
Young chickens inspected (mill.)	3,218.6	3,188.7	3,121.5	2.996.4	3,279.0	3,110.9
Ave. liveweight (lbs. each)	3.77	3.74	3.72	3.65	3.79	3.76
Ante mortem condemn. (% lv.wt.)	.34	.34	.35	.35	.34	.35
Post mortem condemn. (% lv.wt.)	1.59	1.61	1.64	1.67	1.62	1.64
R.T.C. lbs. certified (mill.)	8,782.2	8,629.5	8,399.0	7,908.3	8,991.6	8,460.5
Percentage change	-2.13	-3.83	-6.40	-11.87	+.20	-5.72
Lbs. breeders inspected (mill.)	118.0	118.0	118.0	118.0	118.0	118.0
Ante mortem condemn. (% lv.wt.)	.94	.94	.94	.95	.94	.94
Post mortem condemn. (% lv.wt.)	4.22	4.22	4.23	4.25	4.22	4.23
R.T.C. lbs. breeders certified (mill.)	73.7	73.7	73.7	73.7	73.7	73.7

Table 12. Performance Coefficients and Chick Placement Rates for the U.S. Broiler Subsector Associated with Proposed Restrictions on the Use of Feed Additives in Poultry Rations, 1976 Production Rate.

	Ban at Sub-therapeutic Levels				Ban on Nitrofurans	
	Penicillin		Tetracyclines			
	Moderate Response	High Response	Moderate Response	High Response	Moderate Response	High Response
Breeder replacements (mill.)	33.2	33.8	34.9	37.3	32.3	34.6
Percentage change	+2.47	+4.32	+7.72	+15.12	-.31	+6.79
Mortality (% ave. breeders)	17.5	17.5	17.5	18.0	17.5	17.5
Ave. no. breeders on hand (mill.)	32.1	32.7	33.6	35.5	31.4	33.3
Percentage change	+1.90	+3.81	+6.67	+12.70	-.32	+5.71
Eggs per breeder (no.)	149.3	148.6	147.2	144.6	150.9	147.3
Hatchability, fertility (%)	81.4	81.1	80.2	78.8	82.3	80.3
Chicks hatched (mill.)	3,511.1	3,542.2	3,565.2	3,640.8	3,504.3	3,546.0
Breeder chicks placed (mill.)	35.3	36.1	37.2	39.9	34.5	37.0
Growout mortality (%)	6.10	6.16	6.20	6.32	6.30	6.51
Broiler chick placements (mill.)	3,475.8	3,506.2	3,528.0	3,600.9	3,469.8	3,509.0
Percentage change	+1.20	+2.08	+2.72	+4.84	+1.02	+2.16
Growout mortality (%)	5.38	5.43	5.47	5.58	5.69	5.97
Young chickens inspected (mill.)	3,288.8	3,315.8	3,335.0	3,400.0	3,272.4	3,299.5
Ave. liveweight (lbs. each)	3.77	3.74	3.72	3.65	3.79	3.76
Ante mortem condemn. (% lv.wt.)	.34	.34	.35	.35	.34	.35
R.T.C. lbs. certified (mill.)	8,973.6	8,973.6	8,973.6	8,973.6	8,973.6	8,973.6

would be accompanied by a decrease in broiler meat production as large as 11.87 percent. The ban on use of nitrofurans could be accompanied by a slight increase in quantity of broiler meat production because of improved performance at the breeding stage of production. Comparing the results reported in Table 11 with those in Table 5, in most instances the estimated impact of each restriction is larger in the broiler subsector than in the egg subsector. This is probably because broilers are marketed at an early age and it is when fed to young birds that additives are usually most effective.

Based on the results presented in Table 12, if the proposed restrictions were imposed, substantial increases in breeder flock replacement rates and average numbers of breeders on hand could be required to maintain base period outputs. Under the proposed restrictions on use of tetracyclines, using high efficacy estimates of response to feed additives, increases in rate of breeder replacement and average number of breeders on hand as large as 15.1 and 12.7 percent respectively would have been required to maintain base production. Under the proposed restrictions on use of nitrofurans, based on moderate efficacy estimates of response to feed additives, slight decreases could have occurred in the breeder replacement rate and the average number of breeders on hand while maintaining the base production period output level. Even under this scenario, however, there was a need to house an increased number of chicks to maintain the base period output level.

Estimates of feed use in broiler production during the base production period and expected feed use associated with the proposed restrictions are summarized in Table 13. In most instances when base production period breeder replacement rates were maintained, the proposed restrictions were accompanied by decreases in total feed use. The decreases, however, were not as large as the decreases in broiler output. Thus, when the proposed restrictions were imposed, feed use per pound of broiler meat increased in all instances. When the base production period output level was maintained, each of the proposed restrictions was accompanied by increases in both total feed use and feed use per pound of broiler meat produced compared to feed use in the base production period.

Table 14 includes estimates of broiler production costs during the base production period and costs associated with each of the proposed restrictions. In all instances, imposition of the proposed restrictions was associated with increases in costs per pound of broiler meat. As in the egg subsector, the changes in costs per pound of meat associated with the proposed restrictions were smaller when the base period output level was maintained than those estimated when the base period breeder replacement rate was maintained. This was explained by use of the same estimates of total fixed costs under both assumptions. It was estimated that imposition of the proposed restrictions would be accompanied by an increase in costs per pound of broiler meat as large as 7.8 percent at the base period breeder replacement rate. At the base period output level, the comparable estimated increase in costs was 6.0 percent.

Table 13. Annual Feed Use in the U.S. Broiler Production Subsector Associated with Proposed Restrictions on Use of Feed Additives in Poultry Rations, 1976.

	1976	Ban at Sub-therapeutic Levels				Ban on	
		Penicillin		Tetracyclines		Nitrofurans	
	Base Data	Moderate Response	High Response	Moderate Response	High Response	Moderate Response	High Response
Pounds of feed per:							
Breeder replacement	34.4	34.6	34.8	34.8	35.3	34.5	34.8
Average breeder on hand	111.8	112.3	112.8	113.7	115.7	111.6	112.5
Lb. of broiler inspected	2.10	2.12	2.13	2.15	2.21	2.11	2.13
	1976 Breeder Replacement Rate						
Million tons of feed for:							
Breeder replacements	.557	.561	.564	.564	.572	.559	.564
Breeders	1.761	1.769	1.773	1.785	1.811	1.758	1.766
Broiler growout	13.014	12.862	12.701	12.483	12.085	13,111	12.457
Total	15.332	15.192	15.038	14.832	14.468	15.428	14.787
Percentage change		-.91	-1.92	-3.26	-5.64	+.63	-3.55
Lbs. feed per lb. RTC meat	3.417	3.460	3.485	3.532	3.659	3.432	3.512
Percentage change		+1.26	+2.00	+3.36	+7.08	+.44	+2.78
	1976 Broiler Output Level						
Breeder replacements	.557	.574	.588	.607	.658	.557	.602
Breeders	1.761	1.802	1.844	1.910	2.054	1.752	1.873
Broiler growout	13.014	13.142	13.207	13.337	13.713	13.084	13.213
Total	15.332	15.518	15.639	15.854	16.425	15.393	15.688
Percentage change		+1.21	+2.00	+3.40	+7.13	+.40	+2.32
Lbs. feed per lb. RTC meat	3.417	3.459	3.486	3.533	3.661	3.431	3.496
Percentage change		+1.23	+2.02	+3.39	+7.14	+.41	+2.31

Table 14. Annual U.S. Broiler Production Subsector Costs Associated with Proposed Restrictions on Use of Feed Additives in Poultry Rations, 1976.

	1976 Base Data	Ban at Sub-therapeutic Levels: Penicillin, Moderate Response	Ban at Sub-therapeutic Levels: Penicillin, High Response	Ban at Sub-therapeutic Levels: Tetracyclines, Moderate Response	Ban at Sub-therapeutic Levels: Tetracyclines, High Response	Ban on Nitrofurans: Moderate Response	Ban on Nitrofurans: High Response
	1976 Breeder Replacement Rate						
Cost-Mill. dollars for:*							
Breeders: Feed	265.9	267.1	267.7	269.5	273.5	265.5	266.7
Flock replacement	94.0	94.0	94.0	94.0	94.0	94.0	94.0
Other	20.1	20.1	20.1	20.1	20.1	20.1	20.1
Broilers: Feed	2,186.4	2,160.8	2,133.8	2,087.1	2,030.3	2,202.6	2,092.8
Chicks	380.0	381.2	381.8	383.6	387.6	379.6	380.8
Other	422.9	422.9	422.9	422.9	422.9	422.9	422.9
Cost per RTC lb.(cents)	33.3	33.8	34.1	34.6	35.9	33.4	34.2
Percentage change		+1.50	+2.40	+3.90	+7.81	+.30	+2.70
	1976 Broiler Meat Output Level						
Breeders: Feed	265.9	272.1	278.4	288.4	310.2	264.6	282.8
Flock replacement	94.0	96.3	98.0	101.2	108.2	93.7	100.3
Other	20.1	20.1	20.1	20.1	20.1	20.1	20.1
Broilers: Feed	2,186.4	2,207.9	2,218.8	2,240.6	2,303.8	2,198.1	2,219.8
Chicks	380.0	388.5	396.5	409.7	438.5	378.4	403.2
Other	422.9	422.9	422.9	422.9	422.9	422.9	422.9
Cost per RTC lb (cents)	33.3	33.6	33.9	34.2	35.3	33.4	33.9
Percentage change		+.90	+1.80	+2.70	+6.01	+.30	+1.80

*Feed prices: Breeder = $151.00 per ton (estimated), Broiler growout = $168.00 per ton (55), Breeder replacements @ $2.90 each (estimated).

Turkey Production Subsector

Frequencies of use in turkey production of the feed additive groups included in the proposed restrictions as estimated in this study are reported in Tables 15, 16, and 17. Also reported in these tables are estimated rates of response to use of each additive group among turkeys which received additives in the group during the base production period and industry average production performance rates during the base production period.

It was estimated that relatively low proportions of turkeys over 8 weeks old received rations supplemented with any one of the additive groups included in the proposed restrictions. Reported in Table 15, the estimated percentage of turkey breeders receiving rations supplemented with the three additive groups was the same for all groups. The tetracyclines were estimated to be slightly more effective than either of the other additive groups in improving reproductive performance among turkeys. Again, at the moderate response level, use of nitrofurans in poultry rations was estimated to be accompanied by a decrease in reproductive performance. The responses of feed efficiency, mortality and condemnation rates to use of each additive group were estimated to be small and about the same for all groups.

The estimates of proportions of turkeys over 8 weeks old being grown out for turkey meat which received tetracyclines or nitrofurans in their rations, reported in Table 16, were slightly higher than those for breeding turkeys. Again the estimates of response of production performance rates to use of additive groups included in the

Table 15. Frequency of Use and Rates of Response to Use of Selected Feed Additives and Base Production Performance Rates: Turkey Breeders - 24 Weeks Old and Older.

	Additives					
	Penicillin		Tetracyclines		Nitrofurans	
Percentage of birds using	15		15		15	
	Response Level					
	Moderate	High	Moderate	High	Moderate	High
	Percentage Improvement					
Effect on birds using:						
Reproductive performance	3	6	6	10	-5	5
Feed efficiency	2	5	2	5	1	2
Mortality	1	2	1	2	1	2
Condemnations	2	4	2	4	2	4

Base performance rates

1) Reproductive performance: % eggs produced per hen used for hatching times eggs produced per hen times percentage hatchability, fertility.
   Light breeds = (.9 x 160.0 x .673) = 96.9
   Heavy breeds =(.9 x 160.0 x .719) = 103.5
2) Feed efficiency: Heavy breeds = 140.0 lbs. feed per replacement hen; 288.0 lbs. feed per average breeder on hand.
   Light breeds = 83.4 lbs. feed per replacement hen; 140.0 lbs. feed per average breeder on hand.
3) Mortality: 15.0% of average number of breeders on hand.
4) Condemnations: Ante mortem = .23% of pounds liveweight inspected.
   Post mortem = 2.05% of pounds liveweight inspected.

Table 16. Frequency of Use and Rates of Response to Use of Selected Feed Additives and Base Production Performance Rates: Turkeys, Growing Birds, 8 Weeks Old to Market.

	Additives					
	Penicillin		Tetracyclines		Nitrofurans	
Percentage of birds using	10		20		20	
	Response Level					
	Moderate	High	Moderate	High	Moderate	High
	Percentage Improvement					
Effect on birds using:						
Growth rate	2	6	5	8	2	4
Feed efficiency	3	4	5	7	2	4
Mortality	2	5	2	5	5	10
Condemnations	2	5	3	7	4	9

Base performance rates

1) Growth rate: weight gained 8 weeks to market, light breeds marketed as fryer-roasters-5.19 lbs. per bird, heavy breeds (including some light) sold as young/old turkeys-14.27 lbs. per bird.
2) Feed efficiency: fryer-roasters marketed at 16 weeks old, feed consumed 8 weeks old to marketing = 2.41 lbs. per lb. of weight gained after 8 weeks old; young-old turkeys marketed at 24 weeks old, feed consumed 8 weeks old to marketing = 3.48 lbs. per lb. of weight gained after 8 weeks old.
3) Mortality: Light breeds = 3.5% of 8 week old poults housed.
   Heavy breeds = 6.6% of 8 week old poults housed.
4) Condemnations: Ante mortem = .23% of liveweight pounds inspected.
   Post mortem = 2.05% of liveweight pounds inspected.

Table 17. Frequency of Use and Rates of Response to Use of Selected Feed Additives and Base Production Performance Rates: Turkeys, Poults, 0-8 Weeks Old.

	Additives					
	Penicillin		Tetracyclines		Nitrofurans	
Percentage of birds using	30		30		90	
	Response Level					
	Moderate	High	Moderate	High	Moderate	High
	Percentage Improvement					
Effects on birds using:						
Growth rate	4	8	5	10	2	5
Feed efficiency	3	5	7	12	2	5
Mortality	4	10	2	10	40	60

Base performance rates:

1) Growth rate: Light breeds = 4.0 lbs. each at 8 weeks old.
   Heavy breeds = 5.0 lbs. each at 8 weeks old.
2) Feed efficiency: Light breeds = 8.0 lbs. of feed per 8 week old poult.
   Heavy breeds = 10.0 lbs. of feed per 8 week old poult.
3) Mortality: 4.0% of day old poults started.

proposed restrictions were relatively low. Among additive groups and production performance criteria, it was estimated that the largest responses in turkey growout were changes in mortality and condemnation rates associated with use of nitrofurans. Again, this comparison must be made with caution since the proposed restrictions on use of nitrofurans include therapeutic uses while those proposed for the other additive groups would be in force against sub-therapeutic level use only.

The most frequent use of feed additives included in the proposed restrictions in turkey production was estimated to be for supplementing rations fed to poults less than 8 weeks old. Proportions of poults fed rations supplemented with penicillin or tetracyclines, reported in Table 17, were estimated to be the same, 30.0 percent. Among poults use of these additive groups was estimated to be somewhat more effective than use of the nitrofurans for improvement in growth rates and feed efficiency. Nitrofurans, however, were estimated to be fed to 90.0 percent of all poults and their use was estimated to be far more effective in reducing mortality rates than use of either of the other additive groups.

Base production period turkey output and industry average production performance data are summarized in Table 18. The table also includes expected output and production performance associated with imposition of the ban on use of nitrofurans in turkey rations. The high efficacy estimates of the response of turkey production performance to use of nitrofurans were used in the calculations. It was assumed that imposition of the proposed restrictions would not cause changes in initial breeder stocks and breeder slaughter rates. These data will not be repeated in later tables. In the turkey subsector, however, breeder slaughter was assumed to be part of the final product. Thus, the pounds of breeders slaughtered were added to the pounds of meat turkey slaughtered in each scenario. Comparing production performance rates for the base period with those expected under the ban on use of nitrofurans, reported in Table 18, it is clear that the largest impact of the ban is its effect on poult mortality.

Table 19 includes expected subsector performance coefficients and output levels associated with the proposed restrictions on use of feed additives. These data were calculated assuming there were no changes in the breeder flock replacement rate accompanying imposition of the restrictions. In all instances, the restrictions were associated with decreases in final output. The largest decrease in output, 8.91 percent, was associated with the restrictions on use of nitrofurans. Relatively large decreases were associated with restrictions on the other additive groups, however, accounted for by their efficacy in improving growth rates. It should be noted that in each instance imposition of the restrictions was accompanied by an increase in mortality rate among breeders. The increases, however, were less than .1 percent and do not show in the tabulated data.

Table 20 includes estimated poult placement rates required with each restriction to maintain the base period final output level. To maintain the base period output level, it was estimated that under the

Table 18. Effect of Banning Supplementation of Poultry Rations with Nitrofurans on U.S. Annual Turkey Meat Output, High Response.

	1976 Base Data		Nitrofurans Banned: Base Breeder Replacement Maintained		Nitrofurans Banned: Base Output Maintained	
	Light Breeds	Heavy Breeds	Light Breeds	Heavy Breeds	Light Breeds	Heavy Breeds
Breeder hens on 1st of month (thous.)	196.0	1,259.1	196.0	1,259.1	196.0	1,259.1
Breeder hen replacements (thous.)	319.8	2,057.1	319.8	2,057.1	345.0	2,197.7
Breeder slaughter (thous.)	290.4	1,868.4	290.4	1,868.4	290.4	1,868.4
Mortality (% ave. breeders)	15.0	15.0	15.0	15.0	15.0	15.0
Ave. breeders on hand (thous.)	196.0	1,259.0	195.9	1,258.4	217.9	1,380.6
Eggs per breeder (no.)	160.0	160.0	158.9	158.9	158.9	158.9
Eggs set (mill.)	28.2	181.3	28.0	180.0	31.2	197.4
Hatchability, fertility (%)	67.3	71.9	65.9	71.4	65.9	71.4
Poults hatched (mill.)	19.0	130.0	18.5	128.5	20.5	141.0
Breeder replacements (thous.)	340.2	2,188.4	372.3	2,394.7	401.7	2,558.5
Mortality (%)	6.00	6.00	14.1	14.1	14.1	14.1
Meat poults placed (mill.)	18.7	128.2	18.1	126.1	20.1	138.4
Mortality to 8 weeks (%)	4.00	4.00	9.40	9.40	9.40	9.40
Ave. lv. wt. at 8 weeks (lb.)	4.00	5.00	3.83	4.79	3.83	4.79
No. 8 week old poults (mill.)	17.9	123.0	16.4	114.2	18.2	125.4
Mortality after 8 weeks (%)	3.50	6.60	3.58	6.75	3.58	6.75
Wt. gain after 8 weeks (lb.)	5.19	14.27	5.15	14.16	5.15	14.16
Meat turkeys sold (mill.)	17.3	114.9	15.8	106.5	17.6	116.9
Meat turkeys inspected (mill.)	12.6	119.6	11.7	110.7	12.8	121.7
Ave. lv. wt. (lbs.)	9.19	19.27	8.98	18.95	8.98	18.95
Lbs. inspected (mill.)	116.0	2,304.0	104.9	2,096.9	115.4	2,305.8
Lbs. breeders inspected (mill.)		41.6		41.6		41.6
Ante mortem condemn. (% lv. wt.)	.23		.23		.23	
Post mortem condemn. (% lv. wt.)	2.05		2.09		2.09	
RTC lbs. turkey certified (mill.)	1,955.8		1,781.6		1,955.8	
Percentage change			-8.91			

Table 19. Performance Coefficients and U.S. Turkey Meat Production Levels Associated with Proposed Restrictions on Use of Feed Additives in Poultry Rations, 1976 Breeder Replacement Rate.

	Ban at Sub-therapeutic Levels				Ban on Nitrofurans	
	Penicillin		Tetracyclines			
	Moderate Response	High Response	Moderate Response	High Response	Moderate Response	High Response
Breeder replacements (thous.)						
Light	319.8	319.8	319.8	319.8	319.8	319.8
Heavy	2,057.1	2,057.1	2,057.1	2,057.1	2,057.1	2,057.1
Mortality (% ave. breeders)	15.0	15.0	15.0	15.0	15.0	15.0
Ave. no. breeders on hand (thous.)						
Light	195.9	195.9	195.9	195.9	195.9	195.9
Heavy	1,258.7	1,258.4	1,258.7	1,258.4	1,258.7	1,258.4
Eggs per breeder (no.)	159.3	158.6	158.6	157.8	161.3	158.9
Hatchability, fertility (%)						
Light	67.0	66.7	66.7	66.4	66.9	65.9
Heavy	129.2	128.1	128.1	126.7	132.5	128.5
Breeder replacements (thous.)						
Light	340.5	340.9	340.3	340.9	353.7	372.3
Heavy	2,190.1	2,193.1	2,189.3	2,193.1	2,275.5	2,394.7
Mortality (%)	6.08	6.20	6.04	6.20	9.60	14.10
Meat poults placed (mill.)						
Light	18.5	18.3	18.3	18.1	18.7	18.1
Heavy	127.0	125.9	125.9	124.5	130.2	126.1
Mortality to 8 weeks (%)	4.05	4.13	4.02	4.07	6.40	9.40
Ave. lv. weight at 8 weeks (lbs.)						
Light	3.95	3.91	3.94	3.89	3.93	3.83
Heavy	4.94	4.89	4.93	4.86	4.91	4.79
No. 8 week old poults (mill.)						
Light	17.7	17.6	17.6	17.4	17.5	16.4
Heavy	121.9	120.7	120.8	119.5	121.9	114.2
Mortality after 8 weeks (%)						
Light	3.51	3.52	3.52	3.54	3.54	3.58
Heavy	6.61	6.63	6.64	6.67	6.67	6.57
Wt. gain after 8 weeks (lbs.)						
Light	5.18	5.16	5.14	5.11	5.17	5.15
Heavy	14.2	14.2	14.1	14.1	14.2	14.2

Table 19. Continued

	Ban at Sub-therapeutic Levels				Ban on Nitrofurans	
	Penicillin		Tetracyclines			
	Moderate Response	High Response	Moderate Response	High Response	Moderate Response	High Response
No. meat turkeys inspected (mill.)						
Fryer/Roaster	12.5	12.4	12.4	12.2	12.5	11.7
Young/Old	118.4	117.2	117.4	116.0	118.1	110.7
Ave. lv. wt. (lbs. each)						
Fryer/Roaster	9.13	9.07	9.08	9.00	9.10	8.98
Young/Old	19.2	19.1	19.1	18.9	19.1	19.0
Lbs. breeders inspected (mill.)	41.6	41.6	41.6	41.6	41.6	41.6
Ante mortem condemn. (% lv. wt.)	.23	.23	.23	.23	.23	.23
Post mortem condemn. (% lv. wt.)	2.05	2.06	2.06	2.08	2.07	2.09
R.T.C. lbs. turkey certified (mill.)	1,928.3	1,899.2	1,899.9	1,863.9	1,917.2	1,781.6
Percentage change	-1.41	-2.89	-2.86	-4.70	-1.63	-8.91

Table 20. Performance Coefficients and Poult Placement Rates for the U.S. Turkey Subsector Associated with Proposed Restrictions on the Use of Feed Additives in Poultry Rations, 1976 Production Rate.

	Ban at Sub-therapeutic Levels				Ban on Nitrofurans	
	Penicillin		Tetracyclines			
	Moderate Response	High Response	Moderate Response	High Response	Moderate Response	High Response
Breeder replacements (thous.)						
Light	326.0	326.6	326.6	330.9	327.2	345.0
Heavy	2,078.0	2,100.3	2,100.2	2,129.5	2,083.9	2,197.7
Percentage change	+1.02	+2.10	+2.10	+3.51	+1.44	+6.98
Mortality (% ave. breeders)	15.0	15.0	15.0	15.0	15.0	15.0
Ave. no. breeders on hand (thous.)						
Light	198.8	201.8	201.9	205.5	202.4	217.9
Heavy	1,276.8	1,296.0	1.296.2	1,321.4	1,282.0	1,380.6
Percentage change	+1.43	+2.95	+2.97	+4.95	+2.03	+9.87
Eggs per breeder (no.)	159.3	158.6	158.6	157.8	161.3	158.9
Hatchability, fertility (%)						
Light	67.0	66.7	66.7	66.4	66.9	65.9
Heavy	71.6	71.3	71.3	70.9	72.5	71.4
Poults hatched (mill.)						
Light	19.1	19.2	19.2	19.4	19.7	20.5
Heavy	131.1	131.9	131.9	133.1	134.9	141.0
Breeder replacements (thous.)						
Light	344.0	348.2	348.8	352.7	362.0	401.7
Heavy	2,212.4	2,239.1	2,243.1	2,270.3	2,305.2	2,558.5
Mortality (%)	6.08	6.20	6.04	6.20	9.60	14.10
Meat poults placed (mill.)						
Light	18.8	18.9	18.9	19.0	19.3	20.1
Heavy	128.9	219.7	219.7	130.8	132.6	138.4
Percentage change	+.55	+1.17	+1.18	+2.05	+3.48	+8.00
Mortality to 8 weeks (%)	4.05	4.13	4.02	4.07	6.40	9.40
Ave. lv. weight at 8 weeks (lbs.)						
Light	3.95	3.91	3.94	3.89	3.93	3.83
Heavy	4.94	4.89	4.93	4.86	4.81	4.79
No. 8 week old poults (mill.)						
Light	18.0	18.1	18.1	18.3	18.1	18.2
Heavy	123.6	124.3	124.5	125.5	124.1	125.4

Table 20. Continued

	Ban at Sub-therapeutic Levels				Ban on Nitrofurans	
	Penicillin		Tetracyclines			
	Moderate Response	High Response	Moderate Response	High Response	Moderate Response	High Response
Mortality after 8 weeks (%)						
Light	3.51	3.52	3.52	3.54	3.54	3.58
Heavy	6.61	6.63	6.64	6.67	6.67	6.75
Wt. gain after 8 weeks (lbs.)						
Light	5.18	5.16	5.14	5.11	5.17	5.15
Heavy	14.2	14.2	14.1	14.1	14.2	14.2
No. meat turkeys inspected (mill.)						
Fryer/Roaster	12.7	12.7	12.8	12.9	12.7	12.8
Young/Old	120.1	120.8	120.9	121.8	120.5	121.7
Percentage change	+.48	+1.01	+1.12	+1.90	+.82	+1.77
Ave. lv. weight (lbs. each)						
Fryer/Roaster	9.13	9.07	9.08	9.00	9.10	8.98
Young/Old	19.2	19.1	19.1	18.9	19.1	19.0
Lbs. breeders inspected (mill.)	41.6	41.6	41.6	41.6	41.6	41.6
Ante mortem condemn. (% lv. wt.)	.23	.23	.23	.23	.23	.23
Post mortem condemn. (% lv. wt.)	2.05	2.06	2.06	2.08	2.07	2.09
R.T.C. lbs. turkey certified (mill.)	1,955.8	1,955.8	1.955.8	1,955.8	1,955.8	1,955.8

nitrofuran ban, the rate of breeder replacement would be required to increase 7.0 percent and the number of poults placed for meat would be required to increase 8.0 percent. These higher replacement rates would require an increase in average breeders on hand of 9.9 percent.

Table 21 includes estimates of feed use per year and per pound of turkey produced for the base production period. Similar estimates associated with each of the proposed restrictions are also presented. At base period breeder replacement rates, each of the proposed restrictions was associated with a decrease in total feed use. The decreases were not as large as the related decreases in output, however, thus in each instance feed use per pound of turkey produced increased. At the base period output level, it was estimated that each proposed restriction would be accompanied by increases in total feed use as well as feed per pound of meat produced. Changes in feed use associated with the ban on use of nitrofurans were generally larger than those associated with restrictions on use of the other additive groups. The difference was tempered however by the fact that use of nitrofurans exerted most of its effect on mortality rates among poults. At this production stage relatively little feed has been consumed. It was estimated that under the ban on use of nitrofurans, feed use per pound of turkey produced could increase as much as 3.7 percent.

Table 22 includes estimates of turkey production costs during the base production period and costs associated with each of the proposed restrictions. Since feed cost represents about 80 percent of total costs, the estimated effects of the proposed restrictions on costs were similar to those on feed use. In each instance, imposition of the

Table 21. Annual Feed Use in the U.S. Turkey Production Subsector Associated with Proposed Restrictions on Use of Feed Additives in Poultry Rations, 1976.

		1976 Base Data	Ban at Sub-therapeutic Levels: Penicillin Moderate Response	Penicillin High Response	Tetracyclines Moderate Response	Tetracyclines High Response	Ban on Nitrofurans Moderate Response	Nitrofurans High Response
Lbs. of feed per:								
Breeder replacement:*	Light	83.40	84.17	84.72	85.28	86.81	84.93	87.35
	Heavy	140.00	141.30	142.21	143.16	145.73	142.57	146.63
Breeder:	Light	216.00	216.66	217.71	216.66	217.71	216.33	216.66
	Heavy	288.00	288.88	290.27	288.88	290.27	288.44	288.88
Poult at 8 weeks:	Light	8.00	8.07	8.13	8.18	8.33	8.15	8.38
	Heavy	10.00	10.09	10.16	10.23	10.41	10.18	10.47
Lb. gain 8 weeks to Market:	Fryer/Roaster	2.41	2.42	2.42	2.44	2.45	2.42	2.43
	Young/Old	3.48	3.49	3.49	3.52	3.53	3.49	3.51
		1976 Breeder Replacement Rate						
Mill. tons of feed for:								
Breeding		.360	.362	.364	.364	.368	.363	.368
Poults to 8 weeks		.687	.686	.685	.690	.694	.692	.667
Turkey growout		3.048	3.012	2.982	2.991	2.963	3.005	2.832
Total		4.095	4.060	4.031	4.045	4.025	4.060	3.067
Percentage change			-.86	-1.56	-1.22	-1.71	-.85	-5.57
Lbs. per lb. RTC meat**		4.188	4.211	4.245	4.258	4.319	4.235	4.341
Percenrage change			+.55	+1.36	+1.67	+3.31	+1.12	+3.65
		1976 Output Level						
Breeding		.360	.366	.373	.373	.384	.369	.399
Poults to 8 weeks		.687	.696	.705	.711	.729	.705	.733
Turkey growout		3.048	3.056	3.073	3.066	3.112	3.065	3.113
Total		4.095	4.118	4.151	4.150	4.225	4.139	4.245
Percentage change			+.56	+1.37	+1.34	+3.17	+1.07	+3.66
Lbs. per lb. RTC meet**		4.188	4.211	4.245	4.244	4.320	4.233	4.341
Percentage change			+.55	+1.36	+1.33	+3.16	+1.06	+3.65

* Changes calculated at response rates associated with poults 0-8 weeks.
**Includes breeder slaughter.

Table 22. Annual U.S. Turkey Production Subsector Costs Associated with Proposed Restrictions on Use of Feed Additives in Poultry Rations, 1976.

	1976 Base Data	Ban at Sub-therapeutic Levels: Penicillin Moderate Response	Penicillin High Response	Tetracyclines Moderate Response	Tetracyclines High Response	Ban on Nitrofurans Moderate Response	Nitrofurans High Response
		1976 Breeder Replacement Rate					
Costs - mill. dollars for:							
Breeders: Feed*	62.64	62.99	63.34	63.34	64.03	63.16	64.03
Other**	56.70	56.70	56.70	56.70	56.70	56.70	56.70
Turkeys: Feed*	648.89	643.45	638.06	640.49	636.32	643.28	608.83
Poults	119.34	119.69	120.04	120.04	120.73	119.86	120.73
Other	128.70	128.70	128.70	128.70	128.70	128.70	128.70
Cost per RTC lbs.(cents)***	45.86	46.25	46.69	46.80	47.52	46.52	48.17
Percentage change		+.85	+1.81	+2.06	+3.62	+1.43	+5.04
		1976 Output Level					
Breeders: Feed*	62.64	63.68	64.90	64.80	66.82	64.21	69.43
Other**	56.70	57.10	57.44	57.44	57.94	57.21	59.15
Turkeys: Feed*	648.89	652.85	657.37	657.20	668.33	655.98	669.20
Poults	119.34	120.78	122.34	122.34	124.76	121.42	128.58
Other	128.70	128.70	128.70	128.70	128.70	128.70	128.70
Cost per RTC lbs.(cents)***	45.86	46.14	46.45	46.44	47.13	46.33	47.37
Percentage change		+.61	+1.29	+1.26	+2.77	+1.02	+3.29

* Feed price = $174.00 per ton (55).

** Includes replacement breeders. Other costs increased by proportion that breeder stock plus breeder placement rates increased when base output level maintained.

***Includes breeders slaughtered.

proposed restrictions was associated with an increase in costs per pound of turkey produced. At base period breeder replacement levels, under the ban on use of nitrofurans, costs per pound of turkey produced was estimated to increase as much as 5.04 percent while at base period output it was estimated to increase as much as 3.29 percent.

Estimated Impacts of the Proposed Restrictions on the Poultry Sector

In this discussion, unless otherwise stated, economic impacts of imposing the proposed restrictions on use of tetracyclines in egg and broiler production and nitrofurans in turkey production will be considered.

The results of this study indicate that imposition of the proposed restrictions on use of feed additives in poultry rations would be accompanied by higher costs per unit of poultry produced. Cost increases per unit of product could be as large as 1.7 cents per dozen for eggs and 2.6 and 2.3 cents per pound of ready-to-cook meat for broilers and turkeys respectively. These cost increases are based on the assumption that base period breeder replacement rates were continued. If base period output levels were continued, increases in costs per unit of output would be slightly smaller since it was assumed that total fixed costs would not change in the initial year after imposition of the restrictions.

The above changes in costs per unit of output may appear to be relatively small. However, if base period output levels were continued, total production costs would have increased as much as $76.0 million, $175.9 million and $29.6 million for the egg, broiler and turkey subsectors respectively. This represents an increase of up to $281.5 million in total annual poultry production costs. If base production period breeder replacement rates were continued, total production costs could have decreased as much as $81.9 million, $148.5 million and $38.7 million for the egg, broiler and turkey subsectors respectively. These cost reductions, however, would have been accompanied by as many as 349.7 million dozen fewer eggs and 1,065.3 and 174.2 million less ready-to-cook pounds of broiler and turkey meat respectively.

It is beyond the scope of this paper to present a detailed analysis of impacts of the proposed restrictions on poultry prices and demand. Changes in supply and prices for other products which could accompany the restrictions were not estimated. Changes in other determinants of demand such as consumer incomes and tastes and preferences also were not estimated. Typical research results, however, indicate that farm level demands for eggs, broilers and turkeys are all inelastic. Any given percentage changes in supply, all things equal, would be expected to be accompanied by larger percentage changes in farm prices in the opposite direction.

If base period output levels were continued when the proposed restrictions were imposed, all things equal, poultry prices would not immediately change since demand would not be affected. Higher costs, however, would exert pressures on industry profits resulting in output in future periods being decreased. As a result, farm prices for poultry and eggs would probably increase and consumers would probably pay higher prices for smaller quantities of poultry and eggs.

At base period breeder replacement rates, imposition of the proposed restrictions could cause changes in output levels in the initial production period. Imposition of the proposed restrictions on use of tetracyclines could result in decreases in output up to 7.48 and 11.87 percent in U.S. annual egg and broiler production respectively. Imposition of the proposed ban on use of nitrofurans could result in a decrease up to 8.91 percent in U.S. annual turkey output. Estimates of farm level elasticities of demand are -.2332 for eggs, -.7369 for broilers and -.9240 for turkeys. (9) Given these demand elasticities and changes in output, with no changes in demand, imposition of the proposed restrictions would be expected to be accompanied by farm price increases of 32.08, 16.10 and 9.64 percent for eggs, broilers and turkeys respectively in the short run. In each instance, the percentage increase in farm price is greater than the percentage decrease in quantity of output for the subsector. This suggests that imposition of the proposed restrictions could be accompanied by increased total revenue for each poultry production subsector. Though costs per unit of output increased in each subsector, the percentage increases were less than the percentage decreases in output. Thus total costs for each subsector decreased. It appears the output reductions in the short run could actually mean increased profits for the industry <u>taken as a whole</u>.

It is clear that if base year output were continued and the proposed restrictions were enacted, the immediate response would be losses or less profits for the poultry industry. All things equal, however, output decreases would be expected to mean higher farm prices and possible increases in poultry industry profits. But, the distribution of possible profits within the industry is not clear. It is reasonable to assume that similar price increases would go to all producers. Quantity reductions, however, based on the assumptions made in this study, would be borne mostly by those producers who would have used the additives if there were no restrictions. It was estimated, for example, that 40.0 percent of the broilers produced were fed rations supplemented with tetracyclines.

Quantity reductions for producers of these birds, if the use of tetracyclines were restricted, could be over 2.5 times the industry average or almost 30 percent. Since their price increase would be about the same as for other broiler producers, their total receipts, and probably the profitability of their poultry enterprises, would decrease. Some of them would probably be forced to leave the industry. The producers of the other 60 percent of broilers produced would face an improved profit environment. Increased output using other technology would be encouraged for all producers. The new equilibrium would be at a point where the quantity of output was somewhat lower and prices were somewhat higher than those in the base period since cost per unit of output would probably be higher. Again, consumers would probably pay higher prices for somewhat lower quantities of poultry and eggs.

Some Factors Which Could Modify the Estimated Impacts of Imposition of the Proposed Restrictions

Though use of feed additives in poultry rations is an established management practice on many poultry farms, little investigative attention has been addressed to the efficiency of their use in field conditions. This may be because of the low cost of feed additives relative to all other feed ingredients. It may be because of difficulties at the industry level in evaluating returns for their use as preventive medication or even as promotants of increased growth and egg production rates. Whatever the reasons may be for the limited research attention devoted to results of use of feed additives in poultry rations under field conditions, the result is a sparse supply of data to use in an analysis of the practice. This meant that many factors which could have been substantial influences on the results presented here were not explicitly accounted for in the study.

Additivity and interaction effects of the proposed drug restrictions were not considered. A particular flock of birds is not likely to receive all drugs at any given time. It may receive similar drugs at different stages of production or the drug used may vary depending on the age of bird, flock health condition, disease presence in the area or some other consideration. If there were interactions or additive effects of drug use in poultry rations, the impacts reported in this study would be expected to be under-estimated.

Substitutes for the additives discussed in this study were not considered. Allen and Burbee (1) listed some possible substitutes for antibiotics in poultry rations including other anti-microbial agents, arsenic compounds, sulfates and changes in housing and management. The nitrofurans ban was not considered in their study. The efficacy of bacitracin and tylosin as growth promotants for broilers and turkeys was compared to that of penicillin, oxytetracycline and chlortetracycline. They concluded that tylosin and bacitracin were as effective as the other antibiotics for broilers. Bacitracin also appeared to be an effective substitute for the other antibiotics in growth promotion in turkeys up to 8 weeks of age. Results of comparisons of feed efficiency were not conclusive for turkeys and the efficacy of use of these antibiotics in egg production was not evaluated. Also mortality, morbidity, breeder performance and turkey growout after 8 weeks of age were not considered. The antibiotics considered for restrictions both in their study and in the present one were selected because they are similar to drugs used in human medication. One of the other antibiotics they considered, erythromycin, is already in use for internal human medication. Bacitracin is in use for external human medication.

The list of possible substitutes could also include improved breeding and nutritional programs. As recently stated by Hayes, however, two problems associated with suggested substitutes for currently used drugs are (a) some have not been researched as well as currently used drugs and (b) the fact that a substitute has been approved does not mean it would be as effective. (27) Substitutability of alternatives for the drugs currently used is mostly unknown. The costs of using alternatives are not known. It has been suggested, for example, that in new housing facilities there is little response to antibiotic feeding. Deficiencies in sanitation programs because of old, improperly designed housing or lax management have been cited as reasons for antibiotic feeding. (1) The conclusion appears to follow that new housing with birds raised in a sterile, isolated environment could eliminate the need for antibiotic feeding. If this alternative were to replace use of antibiotic feeding certain questions arise including: (1) How often must housing be rebuilt or even relocated? and (2) What degrees of sterility and isolation are necessary or even possible? However, if there are substitutes available for the additives included in the proposed restrictions, whether they are other additives or changes in management practices, their use could temper the impacts of the proposed restrictions.

Producer responses to increased uncertainty and risk are also unknown factors which could not be evaluated in this study. One reason for use of feed additives is for preventive medication. There may be producers who would be unwilling to risk housing chicks, poults or layers without this insurance. Among responses to the survey, it was revealed that producers who did not routinely feed medicated rations sometimes used them in response to rumored or observed disease outbreaks in their regions. A producer may attempt to reduce the risk of losses by improving his production facilities and management practices. If he feels he has no protection against variables beyond his control, however, he may not be willing to risk investment in a poultry enterprise. Many poultry producers have old, fully depreciated buildings and equipment. They may not be tied into the industry by capital investments. Increased risk may encourage them to leave the industry. Producer responses to increased risk could result in increased impacts of the proposed restrictions.

Another source of uncertainty may also influence producer response to restrictions on the use of feed additives. Use of these agents has been an accepted management practice for many years. A substantial proportion of current poultry producers probably have had no production experience prior to the time when these agents became available. If use were restricted, uncertainty about the continued availability of other agents or practices may develop. For example, producers may question the continued availability of any other antibiotics approved as substitutes or of other medications such as coccidiostats or vaccines currently in use but not now being considered for restrictions. For some producers, there may be less incentive to make the necessary investments to continue poultry production.

Restrictions on use of feed additives could lead to higher production costs than indicated by this study. In estimating the initial or short-run effects, it was assumed that changes in costs were associated mostly with changes in amounts of feed used and breeder or layer replacement rates. The effects of changes in mortality rates, growth rates and egg production per bird on total production costs were expressed only through changes in final output levels or flock replacement rates. Other costs including housing and equipment, labor, fuel and electricity, etc. were assumed to be constant in total at the base period level. Allen and Burbee proposed that excessive recycling of litter and inadequate sterilization of facilities were among the inadequacies in sanitation practices of poultry producers. (1) Many broiler producers currently remove the crust from litter after each flock and completely clean their houses only once per year. A change to a complete cleanout after each flock would mean about a five fold increase in litter cost and a substantial increase in cleanout labor and waste disposal costs. In those houses with dirt floors, a "sterile" cleanout would probably require investment in a concrete or similar material floor. While many broiler producers now raise five to six flocks per year, increased down time between flocks would probably decrease the turnover rate to four to five flocks. To the extent that feed additives are used to help control the effect of stress among birds housed at high density, fewer birds per square foot may be housed without them. This would mean higher housing, fuel, electricity and labor costs per bird. These and similar changes in management practices would all mean higher unit output costs.

Producers who do not regularly use feed additives would not necessarily be exempt from effects of restrictions on their use. The restrictions may be accompanied by an increase in the incidence of disease on farms where feed additives had been used. Poultry diseases are often readily transmitted among farms on the clothing of poultrymen, servicemen, feed and supply deliverers or product pickup men. They can be transmitted by wild animals and birds, flies and insects and some can even be carried by the air. Most production units do not function in complete isolation from all others. Restrictions on use of feed additives in poultry rations could result in increased disease risk and mortality for all poultry operations.

The quality of some of the final products may be affected by restrictions on use of feed additives. The effects of poultry diseases are not limited to mortality and quantities of output per unit of input. Laying hens with minor infections may produce a larger proportion of eggs with poor albumen or yolk quality or with thin or weak shells. Similarly, affected meat birds may show increased incidence of poor body conformation, skin color or meat tenderness. These quality changes, could mean decreases in the value of the final product.

Other Factors to be Considered in Evaluation of Feed Additive Use in Poultry Production

Poultry production today takes place in a much different industry structure and physical environment than in the 1940's when the use of feed additives was introduced. The industry has evolved from one of many small units located throughout most geographic locations to one of a reduced number of large units geographically concentrated in certain specialized regions or areas of the country. With the exception of turkeys, virtually all poultry flocks are now housed in confinement. This is also true for an increasing percentage of turkey flocks. These and other changes in the poultry sector have been accompanied by decreasing production costs which have benefitted consumers through greater supplies and relatively low prices for poultry and eggs. The larger, more concentrated production units have also resulted in lower costs for input supply and delivery, product pickup and processing and distribution to the final users. The availability of preventive medication was partially responsible for these changes. Production units with 100 thousand birds or more at a single location are not uncommon. These facilities often represent large investments of $100,000.00 or more. Incentives to make these types of investment could be reduced if, for example in turkey production, there were no means to protect against a salmonella infection which could wipe out the entire flock before diagnosis was completed and therapeutic medication took effect. To the extent that the availability of preventive medication has contributed to the evolution of the poultry industry into a more efficient structure and set of management practices, restrictions on their use could encourage a reversal of the trend resulting in decreasing efficiency and increasing costs.

The ability to respond quickly to disease outbreaks could modify the effects of the proposed restrictions. Hays stated "If you wait until you have a specific problem organism to check for sensitivity patterns, (i.e., to prescribe a particular medication) much of the economic advantage to be gained from the use of the drug has already been lost." (26) He was commenting on restrictions of feed additives in hog rations to those prescribed by a veterinarian in response to a specific disease problem. The implications are also relevant in the poultry industry. This type of limitation on use of certain feed additives in poultry rations has been proposed as an alternative to routine low level feed fortification schedules. Coleman recently estimated the number of veterinarians available to perform this function. (12) Based on 1977 data, he estimated that there were no more than 30,000 veterinarians in the U.S. Of these, slightly over 6,000 were devoted to private practice including large animals and poultry. Over 5,000 of these designated themselves as in an exclusively or predominantly large animal practice. Over 90.0 percent of the veterinarians were associated with the American Veterinary Medical Association. Among them, only 43 veterinarians were estimated to be exclusively engaged in private practice with poultry. Defining commercial size poultry farms as annual sales of 8,000 or more turkeys or 30,000 or more broilers or an annual average of 10,000 or more egg type hens on hand, 1974 U.S. Census data show there were almost 30,000 commercial poultry farms. This is a ratio of almost 700 farms per poultry veterinarian. It is questionable if this ratio would provide adequate diagnostic and prescription service on a timely basis to the poultry industry in addition to services currently performed. Another proposal is for each feed manufacturer which registers to sell medicated feed to retain a veterinarian. This would require commitment of over 9,000 veterinarians, almost one third of all veterinarians, to employment by a feed manufacturer. (12)

Development of new drugs may also be considered an alternative to use of those currently available. Chalquest estimated that in 1968 the cost within the drug industry of each new drug discovered was $7.0 million. (11) Development of a discovery to a saleable product was estimated to take 3 to 5 years and an investment of several million dollars. At current prices, this probably means discovery and development of a new saleable drug would cost over $15.0 million. Coleman reported that in 1975 use of antibiotics was 9.4 million pounds for human medication and 8.9 million pounds for all other uses including animal feed fortification. (12) Expectation of a reasonably long period of use with some certainty of continued approval for use would probably be necessary to encourage the drug industry to continue to develop drugs for animal agriculture. Restrictions on use of currently used drugs without a thorough evaluation of the consequences would do little to maintain the expectation of continued approval of newly developed drugs.

Robertson states "The concept of preventive medication became a practical reality with the commercial availability of Sulfaquinoxaline in 1948. . .Prior to this in-feed protection, it was rare for a flock to reach market with less than 10 percent mortality. Loss to the owner included not only birds that died, but the impaired performance of survivors. Before preventive medication, treatment of coccidiosis consisted of observing symptoms, rendering an accurate diagnosis and prompt treatment, often with a special feed mix. All of this required time and further, the appetite of the birds was impaired to the point that treatment was rarely effective." (48)

Low level administration of feed additives in poultry rations is a management tool. Under certain circumstances, it permits some producers to provide a larger quantity of higher quality product at lower costs than they can without this tool. The poultry industry is a flexible one. If this tool were taken away, it would probably continue to operate. Changes in structure, management procedures and quantity and quality of output would be likely. Consumers would probably receive a reduced supply of lower quality poultry and eggs at higher prices. A more thorough examination of costs and benefits of the use of feed additives is needed before final action on the proposed restrictions is taken.

Summary

Restrictions on subtherapeutic level use of penicillin, chlortetracycline and oxytetracycline in animal feed rations have been proposed. It has been asserted that their use in animal feeds may result in reduced effectiveness of use of similar agents in treatment of human health problems.

A complete ban on use of nitrofurans in animal feeds has also been proposed as a result of findings that use of agents in this additive group produce tumors in laboratory animals. The possibility of drug residue in human foods raises questions about whether use of nitrofurans in animal medication may pose a human health threat. This study was initiated as a part of a broader analysis of the economic implications of imposition of the proposed restrictions on animal agriculture. The primary objective of this analysis was to estimate the possible impact of these restrictions on the poultry industry.

Limited availability of data on the extent of use and efficacy of feed additives in commercial poultry production was a major obstacle encountered in this study. Data used were collected in a survey of poultry scientists supplemented with other data supplied by a private research firm, experimental results of poultry research projects and standards of performance published in poultry management manuals.

Using 1976 as the base production period, breeding flock sizes, replacement rates, and slaughter rates were described for the egg, broiler and turkey production sub-sectors. For each sub-sector, production flock size, replacement rate, slaughter rate and final output were also described. Where available, data from statistical reports were used in these descriptions. Some breeding flock data were calculated based on certain assumptions. Production performance coefficients such as mortality rates, egg production per layer, hatchability rates, growth rates, slaughtering plant condemnation rates and feed conversion rates were also calculated for each sub-sector. Finally, feed use and production costs were calculated for each sub-sector. Changes in base period production performance rates for the industry which would be expected to accompany the proposed restrictions on use of each additive group were estimated.

Two estimates of the efficacy of use of feed additives in commercial poultry production, a moderate response and a high response, were used to describe separate scenarios. Two industry reactions to the restrictions were analyzed. In one, industry average production performance rates expected if the proposed restrictions were imposed were used to calculate changes in base period output which would occur if base period breeder flock replacement rates were continued. In the other, changes in breeder flock and production flock replacement rates which would have been required if base period output levels were continued were calculated. Estimates of feed use and production costs were calculated for each scenario.

The results of this study suggest that imposition of the proposed restrictions on use of tetracyclines would have the largest impact on the egg and broiler sub-sectors. Under these restrictions, at base period breeder replacement rates, egg output would be expected to decrease as much as 7.5 percent while feed use and production costs per dozen eggs would be expected to increase as much as 3.5 and 3.9 percent respectively.

Broiler meat production would be expected to decrease as much as 11.9 percent while feed use and production costs per pound of ready-to-cook meat would be expected to increase as much as 3.7 and 7.8 percent respectively. If base period output levels were continued increases in feed use and production costs per dozen eggs as mcuh as 4.0 and 3.4 percent respectively would be expected. Increases in feed use and production costs per pound of ready-to-cook broiler meat as much as 3.7 and 6.0 percent respectively would be expected.

The results of this study also suggest that imposition of the proposed ban on the use of nitrofurans in poultry rations would have the largest impact on the turkey sub-sector. At base period breeder replacement rates, a decrease in turkey meat production as much as 8.9 percent accompanied by increases in feed use and production costs per pound of ready-to-cook meat as much as 3.7 and 5.0 percent respectively would be expected. If base period output were continued, increases in feed use and production costs as much as 3.7 and 3.3 percent per pound of ready-to-cook meat would be expected.

If base period breeder replacement rates were continued and the restrictions were imposed, it was estimated that poultry and egg production costs could decrease as much as $269.1 million. However, output would also decrease as much as 349.7 million dozens of eggs and 1,065.3 and 174.2 million pounds of ready-to-cook broiler and turkey meat respectively. If base period output were continued it was estimated that poultry production costs could increase as much as $281.5 million.

It was concluded that imposition of the proposed restrictions would probably result in consumers paying higher prices for smaller quantities of poultry and eggs. The exact estimates of the impact of these changes, however, may be somewhat low due to the nature of some assumptions used in this study made necessary by data limitations. The assumptions that there would be no substitutes for the additives considered and no substitutability among additive groups could have resulted in over-estimation of the possible impacts of restrictions on use of individual additive groups. On the other hand, the assumptions that there were no interactions or additivity in effects of additive groups and that only those birds which would have received supplemented rations would be affected by imposition of the restrictions may have resulted in under-estimation of the potential impacts of the restrictions. Furthermore, though much has been written about feed additives, patterns of use, efficacy of use and alternatives to their use, much of it has been experimental or promotional. There is a need to collect additional information on performance of feed additives under commercial poultry production conditions.

Recommendations for Further Research

The advisability of use of certain feed additives in animal agriculture has been a recurring question for many years. As early as 1960, the Netherthorp Committee in the United Kingdom investigated the possible human health consequences of feeding antibiotics to farm animals. Evaluations of the possible economic costs of restrictions on the use of feed additives in animal agriculture, however, have been limited by a lack of appropriate technical data. The study reported here was performed under the same limitations. The results should thus be evaluated with extreme caution.

Past reports have included recommendations for research to provide more adequate technical data. Allen and Burbee, for example, recommended a publicly funded research program to evaluate all feed additives currently approved as growth promotants to determine: (1)

1. Differences between control and additive treated animals during production to determine feed efficiency and growth rates and differences in quality of final product.
2. The residue accumulations in waste discharge and in the carcasses of treated animals to ascertain any potential human, animal and environmental hazards.
3. Animal responses to various levels of additive feeding under controlled and other environmental conditions.
4. Animal responses using a variety of additives singly or in combination.
5. Consumer attitudes to situations where pigmentation or tissue composition is affected by the additive.

Jordon suggests there is a need to increase grants for research on production of quality poultry and eggs without use of medication. (30) He proposes that better environment, genetics, nutrition and management may be among the answers. He suggests, for example, that a subsidy program to encourage the use of wood chips as poultry litter may be one way to make use of new litter with each flock a more practical management alternative.

To the above suggestions, emphasis should be added on the need for field studies. Surveys are needed to determine which drugs are being used, the concentrations at which they are fed, the reasons for their use, the frequencies of their use among farms and the feeding schedules followed. Are there geographic differences in patterns of use? Are there particular house types, environmental conditions, sizes of houses or farms, seasons of the year, management practices, strains or health conditions of the birds or other variables associated with modification of response rates? What do the producers who use feed additives believe about them? Why do some producers use them while others do not? If feed additive use were restricted by government edict, would there be a need for a public funded indemnity program to maintain producer confidence and protect producers from disease losses which stem from causes outside of their control? Would there be a need for additional educational programs to keep producers aware of substitute management methods, nutritional programs and other changes as they became available to offset any losses of efficiency which may be associated with restrictions on use of feed additives?

There are also questions about what changes in total use of medication in animal agriculture may accompany restrictions on preventive medication. Decreases in low level medication for disease prevention could be completely offset by increases in use of heavier dosages for therapeutic purposes if the incidence and severity of disease increase. The problem could be magnified if a veterinarian's prescription were required before medication was administered because of the limited number available. The more advanced the disease is by the time of diagnosis, the heavier the dosage is likely to be for its treatment. Improved knowledge of the most likely diseases to threaten the poultry industry as it currently operates and the probabilities of their outbreak may provide a basis to evaluate this possibility.

Under the assumptions used in this study, it was estimated that restrictions on preventive medication in animal agriculture could cost the poultry industry almost $300 million in the initial production period if base period output levels were maintained. The cost increase could eventually be passed on to consumers in some combination of increased prices and reduced quantities of poultry and egg products. A comprehensive study of patterns of medication through feed in animal agriculture, including programs for development of alternatives to maintain or improve industry performance, may provide a basis to offset all or part of this cost increase. Data from these studies could also provide a more reliable basis on which to estimate the impacts of restrictions on use of feed additives on the poultry industry and on consumers of its products.

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Appendix

Data on frequencies of use and efficacy in poultry production of the additives included in the proposed restrictions were obtained in a survey of poultry scientists. Data were also obtained in a review of experimental results. Summaries of data from these sources are presented to demonstrate variations in estimated efficacy of use of these agents. These summaries also provide some information on sources of variation in efficacy of feed additives among flocks of poultry.

Results of Survey of Poultry Scientists

The results of the survey of poultry scientists are summarized in Appendix Tables 1 through 7. The respondents were appraised of the proposed restrictions and requested to provide estimates of:

1. Percentages of all poultry housed in the U.S. in 1976 which were fed rations supplemented with additives included in the groups which would be subject to the proposed restrictions. Separate estimates were requested for the egg production, broiler production and turkey production subsectors. Within subsectors, separate estimates were requested for the breeding, replacement growout and final product stages of production.

2. Percentages of improvement in specified production performance criteria among birds which received rations in 1976 supplemented with feed additives included in the proposed restrictions. Separate estimates were requested for each subsector by stage of production and additive group.

Review of Experimental Results

1. Egg production

Heywang (29) reported that addition of penicillin to the laying ration fed to a high producing, low mortality strain of layers produced no significant difference in rate of lay. When fed to a low producing, high mortality strain of layers, however, production response was

Table A-1. Percentages of Chicken Breeders Fed Rations Supplemented with Penicillin, Tetracyclines or Nitrofurans and Changes in Production Performance Associated with Use of these Additives, Field Conditions, Survey Results.

	Penicillin	Tetracyclines	Nitrofurans
Percentage of all birds receiving any (range)	10 to 20	20 to 40	10 to 20
Performance criterion	(range of estimates of percentages improvement)		
Reproduction	0 to 12	0 to 10	-4 to 18
Feed efficiency	0 to 10	0 to 10	-1 to 3
Mortality	2 to 10	2 to 10	2 to 10
Condemnations at slaughter	0 to 5	0 to 5	0 to 5

Table A-2. Percentages of Layer Replacement Pullets, 0 to 20 Weeks Old, Fed Rations Supplemented with Penicillin, Tetracyclines or Nitrofurans and Changes in Production Performance Associated with Use of these Additives, Field Conditions, Survey Results.

	Penicillin	Tetracyclines	Nitrofurans
Percentage of all birds receiving any (range)	10 to 20	15 to 30	10 to 20
Performance criterion	(range of estimates of percentages improvement)		
Growth rate	0 to 10	0 to 12	0 to 5
Feed efficiency	0 to 8	0 to 8	0 to 5
Mortality	2 to 15	5 to 20	15 to 40

Table A-3. Percentages of Table Egg Layers, 5 Months Old and Older, Fed Rations Supplemented with Penicillin, Tetracyclines and Nitrofurans and Changes in Production Performance Associated with Use of these Additives, Field Conditions, Survey Results.

	Penicillin	Tetracyclines	Nitrofurans
Percentage of all birds receiving any (range)	10 to 20	10 to 30	illegal
Performance criterion	(range of estimates of percentages improvement)		
Egg production	0 to 12	0 to 10	--
Feed efficiency	0 to 10	0 to 10	--
Mortality	0 to 10	0 to 12	--
Condemnations	0 to 2	0 to 2	--

Table A-4. Percentages of Broiler Chickens fed Rations Supplemented with Penicillin, Tetracyclines or Nitrofurans and Changes in Production Performance Associated with the Use of these Additives, Field Conditions, Survey Results.

	Penicillin	Tetracyclines	Nitrofurans
Percentage of all birds receiving any (range)	15 to 20	30 to 90	20 to 30
Performance criterion	(range of estimates of percentages improvement)		
Growth rate	0 to 12	0 to 20	0 to 5
Feed efficiency	0 to 8	0 to 15	0 to 5
Mortality	0 to 15	0 to 15	20 to 40
Condemnations	0 to 15	5 to 15	10 to 20

Table A-5. Percentages of Turkey Breeders Fed Rations Supplemented with Penicillin, Tetracyclines or Nitrofurans and Changes in Production Performance Associated with Use of these Additives, Field Conditions, Survey Results.

	Penicillin	Tetracyclines	Nitrofurans
Percentage of all birds receiving any (range)	10 to 20	10 to 20	10 to 20
Performance criterion	(range of estimates of percentages improvement)		
Reproduction	0 to 6	0 to 10	-10 to 10
Feed efficiency	0 to 5	0 to 5	0 to 2
Mortality	0 to 2	0 to 2	0 to 2
Condemnations	2 to 5	2 to 5	2 to 5

Table A-6. Percentages of Turkey Poults, Up to 8 Weeks Old, Fed Rations Supplemented with Penicillin, Tetracyclines or Nitrofurans and Changes in Production Performance Associated with Use of These Additives, Field Conditions, Survey Results.

	Penicillin	Tetracyclines	Nitrofurans
Percentage of all birds receiving any (range)	25 to 40	25 to 40	50 to 95
Performance criterion	(range of estimates of percentages improvement)		
Growth rate	4 to 8	0 to 10	0 to 8
Feed efficiency	0 to 5	0 to 15	0 to 5
Mortality	3 to 10	2 to 10	30 to 90

Table A-7. Percentages of Meat Turkeys, 8 to 24 Weeks Old, Fed Rations Supplemented with Penicillin, Tetracyclines or Nitrofurans and Changes in Production Performance Associated with Use of these Additives, Field Conditions, Survey Results.

	Penicillin	Tetracyclines	Nitrofurans
Percentage of all birds receiving any (range)	10 to 20	10 to 25	10 to 25
Performance criterion	(range of estimates of percentages improvement)		
Growth rate	0 to 6	0 to 10	0 to 5
Feed efficiency	0 to 5	0 to 9	0 to 5
Mortality	2 to 5	2 to 5	4 to 10
Condemnations	2 to 5	2 to 10	3 to 9

dependent on the season of the year. During the cool months of the year, compared with similar birds fed no additives, the percentage production for layers fed a ration including penicillin was 1.6 percent less in one replicate and 12.2 percent higher in another. During the warm months, addition of penicillin to the ration was accompanied by 13.6 and 17.0 percent increases in percentage of production during two replicates. There was no significant difference in mortality rates. Zavala, et al. (60) fed rations including penicillin during pullet growout only and also during growout plus the laying period. An increase in the percentages of egg production relative to an unmedicated control group was observed for both groups. Slinger, et al. (51) reported there was no performance response to addition of penicillin to growout feed for replacement layers. The lack of response was attributed to the previous feeding of penicillin to practically all birds reared in the experimental pens over the prior 10 years. Mortality was low for all groups and also did not appear to be influenced by the use of penicillin.

In three other studies (16, 20, 32) no significant differences in rates of egg production or feed conversion, egg weight or quality, mortality rates or egg fertility or hatchability were associated with addition of chlortetracycline or oxytetracycline to layer feed rations. The lack of response was attributed to use of healthy, high production strains of birds in the experiments. Guenthner and Carlson (25) reported 8.1 and -7.2 percent changes in the percentages of egg production for floor and cage housed layers respectively compared to unmedicated controls when oxytetracycline was added to the laying ration. They reported no significant differences in egg quality, hatchability or fertility. Essary and Holmes (21) reported a 16.0 percent increase in the percentage of egg production associated with adding chlortetracycline to the layer ration. Reid, et al. (47) reported an 8.5 percent increase in the percentage of egg production and a 1.4 percent decrease in feed per dozen eggs produced associated with adding oxytetracycline to the laying ration.

In 1958, Dean and Stephenson (18) reported addition of furazolidone (NF-180) to layer rations was accompanied by increases in egg production of 1 to 18 percent. They reported no change in feed conversion or hatchability and results concerning egg fertility were inconclusive. Damron, et al. (16) and Willingham and Earle (59) reported no changes in rate of lay or feed conversion associated with addition of NF-180 to layer rations. Damron, et al. attributed the lack of response to use of healthy birds in their experiments. Heywang (29) reported that addition of NF-180 to layer rations of a high production, low mortality strain of birds did not effect their rates of production or mortality. However, when fed to a low production, high mortality strain, percentage egg production increased 3.9 percent in the cool months and 14.9 percent in the warm months. Mortality was not affected. Kondra and Guenter (31) reported results of research studies in which White Leghorns and White Rocks were fed rations with nitrofurizone or NF-180. Neither additive affected egg weight, feed conversion, fertility or hatchability. Percentage production was lower for medicated birds than for unmedicated control birds before and after administering the additives. However, after adding NF-180, percentages of production for treated layers improved relative to the unmedicated control birds. This was also observed when White Rocks received a ration supplemented with nitrofurizone. However, addition of nitrofurizone to the White Leghorn ration was accompanied by a decrease in rate of lay relative to unmedicated controls. Obibuaku, et al. (39) reported that feed supplementation with furadroxyl or NF-180 was accompanied by increased rates of lay. Greatest improvement was observed in the colder months. Furadroxyl was also associated with an increase in eggs laid per pound of feed consumed. Neither additive affected hatchability, fertility or egg weight. Production rates, when a 14 percent protein diet was supplemented with furadroxyl, compared favorably with those obtained with a 16 percent protein diet with no supplement. This suggested there was a protein saving effect associated with furadroxyl supplementation of the diet. Sauer, et al. (49) reported a negative relationship between egg weight gain per week and NF-180 supplementation of the ration fed caged White Leghorns in environmentally controlled housing. Stiles (52) reporting on 3 experiments said that feed supplementation with NF-180 was accompanied by decreases of 5.4, 21.9 and 6.6 percent in percentage of egg production. He reported that the decreases were not significant, however, according to the results of statistical tests used in his analysis. He also reported that diet supplementation with NF-180 did not effect egg quality, shell thickness, frequencies of blood or meat spots or egg fertility. However, there was a statistically significant 2.6 percent increase in the percentage hatchability associated with NF-180 ration supplementation. Boone and Barnett (8) reported that supplementation of layer diets with furadroxyl was accompanied by an 8.2 percent increase in eggs produced per layer and a significant increase in percentage hatchability of eggs set. They observed no changes in egg size, shell thickness or percentage of layer mortality. Some of the results of these studies are summarized in Table A-8.

2. Broiler Production

Combs and Bossard (13) reported that in two experiments, additions of penicillin to broiler mash were not associated with any changes in chick growth or feed conversion rates measured at 28 or 49 days old. In a third experiment in which broilers were raised on used litter, addition of penicillin to the ration was accompanied by an increase in growth rates. Eyssen, et al. (22) reported that addition of penicillin to broiler feed was accompanied by a 5.6 percent increase in weight gain over a 4 week period. Their experiments were conducted in clean quarters in which no birds had been housed in the prior 6 months. Heth and Bird (28) analyzed the results of experiments conducted at a single location over a 10 year period. Feed supplementation with penicillin was associated with about a 9.0 percent increase in body weight. There was no evidence of a change in response associated with feeding successive flocks the same type additive. Marusich, et al. (34) reported that penicillin supplementation of broiler feed was accompanied by no significant changes in 8 week weight gains or feed conversion rates. Nelson, et al. (36) demonstrated a decreasing growth response when successive flocks of broilers were raised in the same environment and fed penicillin supplemented rations over a 3 year period. They hypothesized that there was a buildup of resistant organisms. The same authors (37) reported an increase of 11.5 percent in average weight

Table A-8. Production Performance Response of Laying Hens to Supplementation of Feed Rations with Penicillin, Tetracyclines or Nitrofurans, Experimental Results.[a]

Reference[b]	Experiment	Additive	Percentage Production	Feed per Egg
			(- - percentage change - -)	
29[c]	1	Penicillin	-1.6, 12.2	
	2	Penicillin	13.6, 17.0	
25[d]	1	Oxytetracycline	8.1	
	2	Oxytetracycline	-7.2	
47	1	Oxytetracycline	8.5	-1.4
21	1	Chloratetracycline	16.0	
29[c]	1	NF-180	3.9	
	2	NF-180	14.9	
18	1	Furazolidone	1 to 18	
8	1	Furazolidone	8.2	

[a]Based mostly on data published in Poultry Science.

[b]See References Cited.

[c]A low production-high mortality strain of layers. Experiment 1 - conducted during cool months; Experiment 2 - conducted during warm months.

[d]Experiment 1 - floor birds; Experiment 2 - caged birds.

gain through four weeks when broilers were fed a ration including penicillin. Feed per pound of meat decreased 7.3 percent. Potter, et al. (41) reported increases up to 4.6 percent in 8 week weight gain for broilers fed rations supplemented with penicillin. Weight gain per unit of feed also increased up to 3.3 percent.

Combs and Bossard (13) in two experiments found no response in growth or feed conversion rates among broilers fed rations supplemented with chlortetracycline or oxytetracycline. In a third experiment in which broilers were raised on used litter, there were positive growth responses associated with each additive. Heth and Bird (28) reported increased rates of growth for broilers of about 11.0 percent measured at 3 weeks old associated with adding tetracyclines to their rations. They also reported that there was no loss in efficiency associated with feeding the same additive to successive flocks at the same location over a 10 year period. Quarles, et al. (44) demonstrated that low level feeding of chlortetracycline prior to disease exposure did not compromise its therepeutic efficiency against E. typhimurium induced salmonella infections. In fact, a decreased post infection dosage could be used when birds were fed a supplemented pre-infection ration. Eyssen, et al. (22) reported increases of 4.9 and 5.9 percent in weight gain through 4 weeks of age for broilers fed rations with oxytetracycline. The response depended on the dosage administered. Feed efficiency also improved 2.6 and 5.0 percent in the two experiments. Franti, et al. (23) reported that the addition of oxytetracycline to broiler rations was accompanied by increases in 8 week body weight of 2.1 and 7.1 percent depending on the dosage used. Feed conversion rates were not affected. Prasad, et al. (43) fed broiler breeders rations supplemented with neomycin sulfate and oxytetracycline. They reported that improvements in progeny performance accounted for by improved hatching egg quality were greater than improvements in hen performance. Progeny of hens fed the supplemented diets were better feed converters than those of control hens. Additive supplemented feed for the breeders also accounted for improved growth and liveability and decreased condemnation rates among their progeny.

Bierer (5) demonstrated that low level feeding of nihydrazone enabled broilers to maintain weight gains almost as high as uninfected birds when air-sac infection was artifically induced by exposure to E. Coli organisms. Bierer and Barnett (7) reported results of four experiments in which broiler hatching eggs were sprayed with S. typhimurium broth to induce salmonella infection among chicks hatched. Chick feed was supplemented with a low level dosage of nihydrazone. Average percentages of mortality through 10 days old for chicks which did not receive medication were 34.0, 29.0, 21.5, and 34.0 for experiments 1 through 4 respectively. Comparable rates for those receiving medicated feed were 21.0, 14.0, 13.0 and 7.0 percent respectively. In a fifth experiment, infection was by natural exposure to seeder birds and the disease organism was S. gallinarium. The average percentages of mortality measured at 8 weeks of age were 84.5 for non-medicated birds and 1.5 for those receiving medicated rations. Growth rate for exposed birds which received medicated feed were about the same as those for birds which were not disease exposed and received non-medicated feed. Raines and Porter (45) reported on experiments in several states where air sac disease was recognized. Addition of Nidrafur (nihydrazone) premix to broiler diets aided in maintaining weight gains and feed efficiency and "dramatically reduced" condemnations due to air sac disease lesions. Raines and Porter (46) reported on paired experiments including control flocks which received no medication and treated flocks receiving rations supplemented with low levels of nihydrazone fed continuously from 1 day of age to marketing. Use of the additive was associated with an increase in the percentage liveability by as much as 11.6 percent in one experiment. The average percentage increases associated with the additive for six experiments were 2.5 for percentage liveability and 5.9 for average live weight. Use of the additive was also associated with a 3.3 percent decrease in feed use per pound of meat. The percentage of plant condemnations due to air sac disease was 1.9 for control flocks compared to 0.3 for the treated birds. Briggs (10) reported that low level feeding of HC-067, a nitrofuran, to broilers was associated with a 2.6 percent increase in weight gain through 8 weeks of age. He also stated that preliminary results showed an additive effect of HC-067 with penicillin. Some results of these studies are summarized in Table A-9.

3. Turkey Production

Balloun, et al. (3) reported that addition of a penicillin-streptomycin combination to rations fed to poults was associated with a 3.8 percent increase in body weight measured at 5 weeks old. When fed in combination with dimetridazole, a blackhead disease control agent which also demonstrated

Table A-9. Production Performance Response of Broiler Chickens to Supplementation of Feed Rations with Penicillin, Tetracyclines or Nitrofurans, Experimental Results.[a]

Reference[b]	Additive	Growth Rate	Feed Per lb. Meat	Liveability
		(- - - - percentage change	- - - - - -	-)
22	Penicillin	5.6		
28	Penicillin	9.0		
37	Penicillin	11.5	-7.3	
41	Penicillin	4.6	-3.3	
28	Tetracyclines	11.0		
22	Oxytetracyclines	4.9, 5.9	-2.6,-5.0	
23	Oxytetracyclines	2.1, 7.1		
46	Nihydrazone	5.9	-3.3	2.5
10	HC-067	2.6		
7	Nihydrazone			52.2[c]
7	Nihydrazone			98.2[c]

[a]Based mainly on data published in Poultry Science.

[b]See References Cited.

[c]Included exposure to salmonella organisms.

growth promotant capabilities, the effects of the two agents were additive. Potter (42) reported that penicillin supplementation of poult rations in one experiment was associated with increases in body weight and feed efficiency measured at 8 weeks old of 7.4 and 2.7 percent respectively. In another experiment, similar increases were 8.3 and 3.3 percent respectively. Scott and Peter (50) summarized results of experiments to determine the growth promotant capabilities of various feed additives when fed with a nutritionally complete starter diet. Low level feeding of penicillin was accompanied by an increase of 9.3 percent in turkey growth through four weeks. Sullivan, et al. (53) reported that, in one experiment, addition of penicillin to turkey rations was associated with a 13.0 percent increase in 8 week old poult weights. In a second experiment, addition of penicillin to rations accounted for a 9.0 percent increase in body weight measured at 8 weeks of age while addition of a penicillin-streptomycin combination accounted for a 16.6 percent increase.

Baldwin, et al. (2) reported no significant changes in weight gain or feed efficiency for turkeys fed rations including low levels of oxytetracyclines. They did conclude from analysis of micro-organisms in the feces that there was an increase in multiple antibiotic resistance when increased amounts of antibiotics were fed. Deacon and Patterson (17) reported a 4.2 percent increase in the percentage of egg production for turkey breeders fed rations including oxytetracycline. They observed no effect on feed used per egg or fertility or hatchability. They attributed the lack of response to the "excellent health" of the birds throughout the test. Nivas, et al. (38) fed clortetracycline supplemented pre-starter rations to turkey poults beginning at 1 day of age. The poults were artifically exposed to salmonella infection by oral application of S. typhimurium at 5 days of age. Tests from 3 days through 12 days after exposure revealed that as the dosage of additive in the diet increased the quantity and duration of shed of salmonella decreased. Minimal levels of drug resistance and resistance transfer to other organisms were also observed. Olson (40) reported that addition of chlortetracycline to the ration reduced mortality for turkeys artificially exposed to fowl cholera disease. The survival rate among non-medicated exposed turkeys was 44.4 percent compared to 70.8 percent among exposed birds fed rations with low levels of the additive. Feed conversion for exposed turkeys fed low levels of the additive was about the same as that for nonmedicated, nonexposed turkeys. Potter (42) reported a 4.9 percent increase in body weights measured at 8 weeks of age for turkeys fed rations supplemented with chlortetracycline. In two experiments, he reported increases of 0.7 and 1.8 percent in 8 week feed efficiency associated with the additive. Scott and Peter (50) reported average weight of poults measured at 4 weeks of age was increased 4.1 percent when rations were supplemented with chlortetracycline. Sullivan, et al. (53) reported a slight decrease, 2.0 percent, in growth of turkey poults through 8 weeks of age when their diet was supplemented with chlortetracycline.

Condren, et al. (14) cited an earlier study in which it was shown that low level feeding of NF-180 before infection was almost totally effective in prevention of artifically induced blackhead in turkeys.

McGregor, et al. (35) fed poults rations supplemented with NF-180 from day old through 25 days old. The poults were exposed to histomoniasis at 15 days of age. Mortality for the disease exposed birds not fed medication was 87.5 percent compared to only 6.2 percent for those exposed but fed rations supplemented with NF-180. Potter (42) reported results of two experiments in which poults were fed rations supplemented with NF-180. Administration of the additive was associated with increases in body weight and feed efficiency measured at 8 weeks of age of 4.1 and 2.3 percent respectively in one experiment. Comparable results in the second experiment were increases of 6.0 and 8.0 percent. The dosage of NF-180 was doubled in the second experiment. Scott and Peter (50) reported that addition of NF-180 to a nutritionally complete turkey starter diet was associated with a 7.7 percent increase in poult growth through four weeks of age. Bierer (6) reported that supplementation of turkey starter ration with nihydrazone was effective in reducing mortality from salmonella infection. In two experiments, day old poults were exposed to S. typhimurium. Mortality after 10 days was 76.0 and 86.0 percent for poults which did not receive medicated feed. For those fed rations supplemented with nihydrazone beginning at one day of age, comparable mortality was 30.0 and 18.0 percent respectively. In a similar experiment in which poults were exposed to S. gallinarium, the mortality rates were 90.0 and 36.0 percent for non-medicated and medicated poults respectively. The degree of protection was associated with the level of medication. Bierer and Barnett (7) used seeder birds for natural exposure of poults to S. gallinarium. Exposure was from 1 through 7 days of age. The average mortality of poults 14 days of age for those receiving no medication was 75.0 percent. For those which were fed rations supplemented with nihydrazone, it was 14.0 percent, actually lower than the 18.0 percent mortality for a group of control birds which was not disease exposed and received no medication. For the disease exposed groups, the average body weight of poults which received medication was as much as 7.6 percent greater than that of those which received no medication. Average body weight of disease exposed, medicated birds was only 2.4 percent less than that of those not exposed nor medicated. Some results of these studies are summarized in Table A-10.

Table A-10. Production Performance Response of Turkeys to Supplementation of Feed Rations with Penicillin, Tetracyclines or Nitrofurans, Experimental Results.[a]

Reference[b]	Additive	Age When Measured	Growth Rate	Feed Per lb. Meat	Liveability
		(weeks)	(- - - - percentage change	- - -)	
3	Penicillin[c]	5	3.8		
53	Penicillin[c]	8	16.6		
42	Penicillin	8	7.4,8.3	-2.7,-3.3	
50	Penicillin	4	9.3		
53	Penicillin	8	13.0,9.0		
42	Chlortetracycline	8	4.9	-.7,-1.8	
50	Chlortetracycline	4	4.1		
53	Chlortetracycline	8	-2.0		
42	NF-180	8	4.1,6.0	-2.3,-8.0	
50	NF-180	4	7.7		
40[d,h]	Chlortetracycline	23		-17.0	59.5
35[e,h]	NF-180	5	60.4		594.8
6[f,h]	Nihydrazone	1.5			191.7,485.7
6[g,h]	Nihydrazone	1.5			640.0
7[g,h]	Nihydrazone	2	7.6		244.0

[a]Based mainly on data published in Poultry Science.

[b]See References Cited.

[c]Penicillin-streptomycin.

[d]Poults exposed to P. multocida to induce fowl cholera.

[e]Poults exposed to Histomoniasis.

[f]Poults exposed to S. typhimurium to induce salmonella infection.

[g]Poults exposed to S. gallinarium to induce salmonella infection.

[h]All comparisons are with control birds exposed to similar disease organisms but receiving no preventive medication.