MINNESOTA TURKEY RESEARCH 1984

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CONTENTS

DEDICATION

ROBERT W. BERG

Minnesota Turkey Research-1984 is dedicated to Dr. Robert W. Berg, Department of Animal Science, University of Minnesota. Dr. Berg, who will retire from the faculty in October, 1984, has been professor and extension poultry specialist since 1958. Bob received his B.S. degree with distinction in Agricultural Economics in 1941. After service in the Army from 1942-1945 he worked with the Minnesota Poultry Improvement Board as poultry inspector and R.O.P. (Record of Performance) supervisor. From 1948-1953 he was a research assistant at the University of Minnesota earning the M.S. and Ph.D degrees.

His Ph.D dissertation was the first comprehensive study on the relationship of live body measurements and meat yield in turkeys. This study demonstrated that the high relationship between live body measurements and meat yield could be used in a breeding program to increase meat yield. Bob gained commercial experience early, spending eight months at Bellevue, Washington, as geneticist for the Western Cooperative Hatcheries and from there he was geneticist and hatchery manager for Jerome Turkey Hatchery, Barron, Wisconsin. In 1958 he joined the University of Minnesota staff as an extension poultry specialist.

Bob has an uncanny perception of the needs of the turkey industry and the ability to size up a variety of situations correctly. He is a low key individual, modest and tolerant, yet very decisive. His personal qualities of unselfishness and unstinting effort have earned the confidence and admiration of all who work with him. His effectiveness stems from his willingness to help and cooperate with producers, colleagues and organizations to get the job done. One of his contributions in Minnesota was the development of the area meeting concept.

Bob has utilized several of the turkey research buildings to make comparisons of litter management, bird density, intermittent lighting, energy savings and numerous other practical projects. A considerable amount of immediately useful information has come from this research and industry has put the information to work quickly. He initiated a total management program that has brought about greater consistency in the production of rapidly growing toms and hens. This program has greatly reduced leg weakness and disease problems in large flocks of turkeys.

Bob is a member of Poultry Science Association and has served on the National Turkey Federation Awards Committee and was chairman of that committee in 1963. He was section chairman for the extension sessions for the Poultry Science program in 1973. He is a member of the World's Poultry Science Association, Sigma Xi, American Association for the Advancement of Science, Epsilon Sigma Phi and Gamma Sigma Delta. He was the recipient of the Ranelius Award for Outstanding Service to the Minnesota turkey industry in 1963. He has been further recognized for his contribution to the poultry industry by the Poultry Science Association when he was awarded the Pfizer Extension Award in 1983 and made a Fellow of the Association in 1984. The Minnesota Turkey Growers proclaimed him as a Lifetime Member in 1984.

All in all Bob's contribution to Minnesota's and the nations's turkey industry has been of great value. He is a nationally and internationally respected authority and is requested to participate in many meetings.

SEASONAL AEROSOL CONCENTRATIONS IN TURKEY GROWER BARNS

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Introduction

Aerosols and noxious gases in the air of confinement turkey barns are a concern to producers because of their part in airsacculitis. It has been estimated that Minnesota turkey producers lose over $3 million annually due to airsacculitis (Poss, 1983). The establishment of exposure limits and control methods for maintaining aerosols and noxious gases at levels of lower incidence would facilitate a sizable reduction of these losses.

This report will discuss aerosol characteristics, factors and forces that affect their control, their effect on the respiratory tract, and the results of field monitoring in commercial confinement turkey grower barns.

Background

An aerosol, for the purpose of this discussion, is a dispersion of microscopic solid and liquid particles suspended in the air. It includes airborne dust, microorganisms, spores, feed, bits of feathers, dead skin cells, dried feces and water droplets. This extensive list indicates the variety of types and sources of naturally occurring aerosols in confinement turkey barns.

Aerosol particles range in size from .0001 to over 100 microns. The smallest grains of flour that a person can see under normal conditions are between 50 - 100 microns. Most bacteria and molds are between 1 and 2 microns in size. Particle size is important because it predicts how a particle will behave in air. Particles greater than 30 microns tend to settle out of the air in minutes and accumulate on surfaces. Particles between 1 and 20 microns tend to follow the motion of moving air, staying suspended for long periods of time. Particles less than 0.1 micron behave similar to molecules and do not settle out of moving air.

The respirable aerosols that can penetrate deep into a turkey's respiratory tract (1.2 - 2.5 microns), are a major concern because they can be retained there. Smaller particles tend to be exhaled again, while larger ones tend to be removed in the upper respiratory tree.

There are several other important characteristics of aerosols other than size which are important. Aerosol density is important because, along with size, it has a major influence on the settling rate of a particle. Particle shape is significant. Liquid particles are usually spherical. Solid particles can have very complex, irregular shapes; they may be spherical, oblong, or fibrous.

The interaction between aerosols and the components in the air can be very important. Odorous and noxious gases can adhere to the surface of aerosols and increase their concentration several fold above that normally found in the air. Aerosols interact with the moisture in the air.

Liquid aerosols can dry and decrease in size if the relative humidity is low, or increase if high. The effect of moisture in the air on solid aerosols has not yet been determined. Several studies have shown that airborne bacteria have a very high mortality rate in air with a relative humidity of 50 percent (Dunklin and Puck, 1948; Jacobson, 1974).

Naturally occurring aerosols have particles over a range of sizes. The size distribution of an aerosol shows the relationship between the number of small particles to the number of large particles. This information is useful for determining the level of health hazard presented by an aerosol, and for selecting the most effective method of control.

Two other characteristics of aerosols that influence the extent of the health hazard are; 1) the concentration, and 2) the duration of the different concentrations.

Airsacculitis may be the result of exposure to high concentrations of aerosols for short periods of time, or from long term exposure to relatively low concentrations. Threshold limits for people exposed to chemical substances are based on both criteria (ACGIH, 1981).

There are several forces that act on aerosols and can be used to effect some control. Gravity is one such force. Gravity is the force that causes large heavy particles to settle out of the air. Spraying water into the air uses gravity to reduce the aerosol concentration. Particles adhere to the relatively large water droplets and settle out of the air. Moisture also causes particles to adhere to one another in large clumps that cannot become airborne.

Air movement produces another force which acts on aerosols. Technically, it is called 'drag'. Drag causes airborne particles to be carried along with the air. If the drag on a particle is greater than gravity, the particle will not settle out. Aerosol concentrations could be reduced by ventilating a building at a rate sufficient to remove the aerosols with the exhausting air. However, ventilation rate changes should not be made without considering the effect on supplementary heat needs and the relative humidity levels desired within a building.

Aerosols react to electrostatic forces as well. Electrostatic forces produce "static cling". The principle is used in negative ionization systems that have been used for aerosol control, (Enos, et. al. 1981). We have found, however, that ionization increased the retention of particles in the respiratory tract (Table 1).

Other forces include, adhesive, thermal and Brownian motion. Adhesive forces determine the ability of a particle to stick to surfaces and other particles. Aerosols with strong adhesive forces tend to stick together, growing into larger particles that settle out quickly. They also tend to remain attached to surfaces, and do not become re-entrained in the air easily. Thermal forces require extremely high temperatures to be usable. Brownian motion is important for particles less than 0.1 micron and where the air space is very small, as in the respiratory tract.

The effects of inhaled aerosols on the respiratory tract are numerous and may include: 1) interference with mucous production and destruction of the ciliated epithelium of the trachea as occurs with elevated concentrations of ammonia, 2) binding, replication, and invasion of epithelial tissues as seen with certain bacterial infections, 3) germination and invasion of tissues as occurs with Aspergillus organisms, 4) phagocytosis by pulmonary macrophages as occurs with most pathogens and inert particles, and 5) elicitation of allergic responses which probably occurs from inhalation of many of the proteinaceous components of barn dust, (Anderson, 1968). Since airsacculitis lesions containing purulent exudates often are sterile when cultured, there is a possibility that many of the airsacculitis problems seen with confinement turkeys are nothing more than an irritant reaction to noxious foreign materials, (Wilson, 1982).

Development of an effective aerosol control procedure or system will require an understanding of aerosols found in confinement turkey buildings, and forces acting upon them. Baseline "normal" aerosol concentrations need to be determined. Information on the interaction between aerosol concentrations and bird age, temperature, relative humidity, ventilation management and other field data is needed. An aerosol control system must fit into the production schedule, ventilation system and management of commercial turkey barns to be viable.

Field Monitoring

A HIAC/ROYCO airborne particle counter (sampler model 4100 and sensor model 1200) was used to measure respirable particle concentrations during the past winter and summer.

The unit was placed in commercial turkey grower barns located in west central Minnesota. The barns usually held 5,000 birds. Air samples taken from approximately turkey-head height were fed into the sensor through tygon tubing.

The winter sampling procedure was to count the number of particles in the air flowing through the sensor for five minutes, four times per hour. Three grower barns were sampled on separate days; once a week for approximately 24 hours.

The summer concentrations were measured in one grower barn. Again, five minute samples were taken four times an hour for approximately 24 hours. The measurements were made once a week on varying days as part of an extensive monitoring schedule.

The counter had six channel settings corresponding to particle sizes. The channels were set to count the number of particles between 0.5 - 1.2, 1.2 - 2.5, 2.5 - 3.5, 3.5 - 5, 5 - 10 and greater than 10 microns. The concentration of particles per cubic foot was calculated using the number of particles counter, sampling air flow rate and the sampling time.

In addition to quantifying the aerosol load in these facilities, we have attempted to determine the physical, organic, and chemical content of these aerosols. All-glass impingers, Anderson samplers and settle plates were used to determine the number of bacteria, yeast and Aspergillus organisms suspended in the air, as well as the total mass of material in the respirable size range. Other equipment was employed to measure the concentrations of gases such as ammonia, methane, carbon dioxide, carbon monoxide, nitrogen dioxide, and hydrogen sulfide. Samples of litter and feed are being quantitatively analyzed for their content of Aspergillus organisms. All of these parameters will be correlated with age, density, and activity levels of the turkeys, ventilation rates, indoor and outdoor temperature and humidity, and general weather conditions.

Results

Table 2 lists the winter daily average particle concentrations for each channel over a four week period for one of the barns monitored. The data shows that the concentration of each channel increased with the bird age. Sadiq (1970) found an increase in airborne microbial contamination in confinement turkey facilities until six weeks of age, after which a gradual decline was seen. Table 2 also shows that the number of particles between 1.2 - 2.5 microns was consistently the greatest. This was significant because particles in this size range are believed to penetrate deeply into the respiratory system and be retained. Similar results were seen in some of the summer data (Table 3) for five to nine week old hens.

Table 4 gives the average concentrations using all of the winter and summer data collected as of August 15th. The winter data includes eleven days of data from three different grower barns. The toms ranged in age from 12 to 18 weeks in January and February. The summer data includes six days of data from a single barn with hens ranging in age from 5 to 14 weeks in June, July and August.

The results demonstrate that the winter and summer data had similar particle size distributions. The concentration of particles between 1.2 - 2.5 microns was the greatest. The data also indicates that the summer concentrations were significantly lower than the winter concentrations. It must be noted that season may not be the only cause of this difference. Bird age and sex was different in both sets of data. The winter concentrations were measured in barns with older toms. The summer concentrations were measured in barns with younger hens. The effect of bird age has already been presented in Tables 2 and 3.

The data in Table 4 does show that the number of larger particles was greater in the summer. The number of particles greater than 5 microns (Channels 5 and 6) was smaller in the winter. The reason for the difference has not been determined. Aerosols brought in with the ventilation air and increased air velocities within the building due to ventilation fans and wind, may partially account for the difference.

Hourly aerosol concentrations for winter and summer for the first four channels are presented in Figures 1 - 4. The values presented are the hourly averages, using all of the winter and summer data. The figures show the differences in concentration between summer and winter, previously seen in Table 4. They also show significant increases in concentrations in the morning and evening. Midday and night time concentrations were lower. The peak concentrations are closer together in the winter, as compared to the summer. The time difference appears to correspond with sunrise and sunset.

Jacobson (1974) found particulate concentrations in turkey facilities to increase with bird activity. It should be noted that these figures are averages. Individual days had significantly different hourly concentration patterns. This fact indicates that factors other than time of day can change the hourly aerosol concentration.

The measuring of the other parameters was a new thrust and the results are incomplete and reflect only a part of the entire picture.

The results of sampling for gases and viable organisms in a grower barn during the summer months has revealed very low levels of the compounds being measured. With the exception of ammonia, all of the other gases (methane, carbon dioxide, carbon monoxide, nitrogen dioxide and hydrogen sulfide), have been below detectable levels. Ammonia has been present in the range of from 5 to 22 ppm with a trend toward increasing levels as the flock approached market age, irrespective of the fact that the barn was "wide open" for the entire summer. However, when compared with results obtained from winter sampling, the summer conditions appear much more favorable for the health and well-being of the respiratory system. Peak winter ammonia concentrations regularly exceeded 50 ppm, and on a few occasions, were over 100 ppm. The occupational standards for ammonia are set at 25 - 50 ppm for an 8 hour exposure period.

The measurement of total and respirable dust in the summer has shown that while the total amount of dust per cubic meter of air has stayed roughly the same, the amount of dust in the respirable size range has increased as the flock gets older. The content of Aspergillus organisms in the air was found to be low and constant in both winter and summer. Whether measured by settle plates, all-glass impingers, or Anderson samplers, the concentration of Aspergillus spores ranged between 0 and 6 colony forming units per cubic foot of air. Despite the low numbers of spores encountered in the air, the recovery of Aspergillus spores from the lungs of turkeys differed significantly between winter and summer. Fewer than 10% of the samples taken in summer yielded positive recoveries while winter samples yielded recoveries ranging between 50 and 70% of the lungs sampled. Thus, there were factors operative during winter conditions that resulted in far greater retention of Aspergillus spores in the lung. Whether this was due to reduced clearance efficiency brought on by overloading the defense mechanisms with foreign material, or an effect of other substances such as ammonia, is not presently known.

Summary

Respiratory disease causes significant losses to turkey producers annually in Minnesota. The contribution of aerosols to the pathogenesis of airsacculitis has not been established, but they appear to be a factor. Understanding the characteristics of, and forces acting upon aerosols, (as well as their interaction with the respiratory system of the host) is essential for the development of aerosol control systems. Such systems must be compatible with the production schedule, ventilation system and management of a commercial turkey barn.

Aerosol concentrations were measured in commercial turkey grower barns during the past winter and summer. The results showed that the greatest concentration was found for the particle size range from 1.2 - 2.5 microns in both the winter and summer. Both seasons also showed an increase in concentration with bird age. The concentration of particles greater than 5 microns was greater in the summer than in the winter. The concentration of particles between 0.5 and 3.5 microns was greater in the winter. The significance of season was not clear because bird age and sex were also different in the barns monitored. Hourly concentration changes were evident, and appeared to be related to bird activity. Other factors that were important, though not identified, could vary the hourly concentration significantly from the average.

Further aerosol monitoring is scheduled to obtain more baseline data and to determine the interaction of more environmental factors, such as temperature, wind, and relative humidity. Work is also underway to accurately describe the ventilation of commercial turkey grower barns to correlate ventilation with aerosol concentrations.

Table 1. A comparison of the retention of fungi and bacteria in the lungs of turkeys reared in facilities with and without negative ionization. There was significantly more retention among birds exposed to ionization.

Group	Number Birds with positive *A. fum.*	Ave. CFU's *A. fum.* per lung (x 50)	Number Birds with positive bacteria	Ave. CFU's bacteria per lung (x 50)
Ionized	6/15	887	15/15	3309
Non-ionized in ionized bldg.	3/16	53	15/16	464
Non-ionized control in separate bldg.	0/16	0	15/15	201
Condemned birds	10/10	6367	10/10	20262

Table 2. Winter daily average particle concentrations (million particles/cubic foot)

Channel	Size (microns)	Bird Age (weeks) 14	15	16	17
1	0.5 - 1.2	3.146	3.875	8.532	10.443
2	1.2 - 2.5	6.295	8.602	19.726	24.794
3	2.5 - 3.5	1.191	1.812	4.664	5.877
4	3.5 - 5.0	0.383	0.682	1.791	2.285
5	5.0 - 10.0	0.036	0.074	0.266	0.356
6	10.0	0.001	0.003	0.028	0.048

Table 3. Summer daily average particle concentrations (million particles/cubic foot)

Channel	Size (microns)	Bird Age (weeks) 5	6	7	9
1	0.5 - 1.2	0.912	0.397	0.485	0.909
2	1.2 - 2.5	1.598	1.558	1.907	4.172
3	2.5 - 3.5	0.638	0.751	0.976	2.220
4	3.5 - 5.0	0.558	0.639	0.843	1.800
5	5.0 - 10.0	0.265	0.305	0.404	0.770
6	10.0	0.130	0.144	0.183	0.297

Table 4. Average winter and summer particle concentrations. (million particles/cubic foot)

Channel	Size (microns)	Winter	Summer
1	0.5 - 1.2	5.678	0.959
2	1.2 - 2.5	13.038	4.084
3	2.5 - 3.5	3.032	2.138
4	3.5 - 5.0	1.165	1.744
5	5.0 - 10.0	0.159	0.697
6	10.0	0.014	0.227

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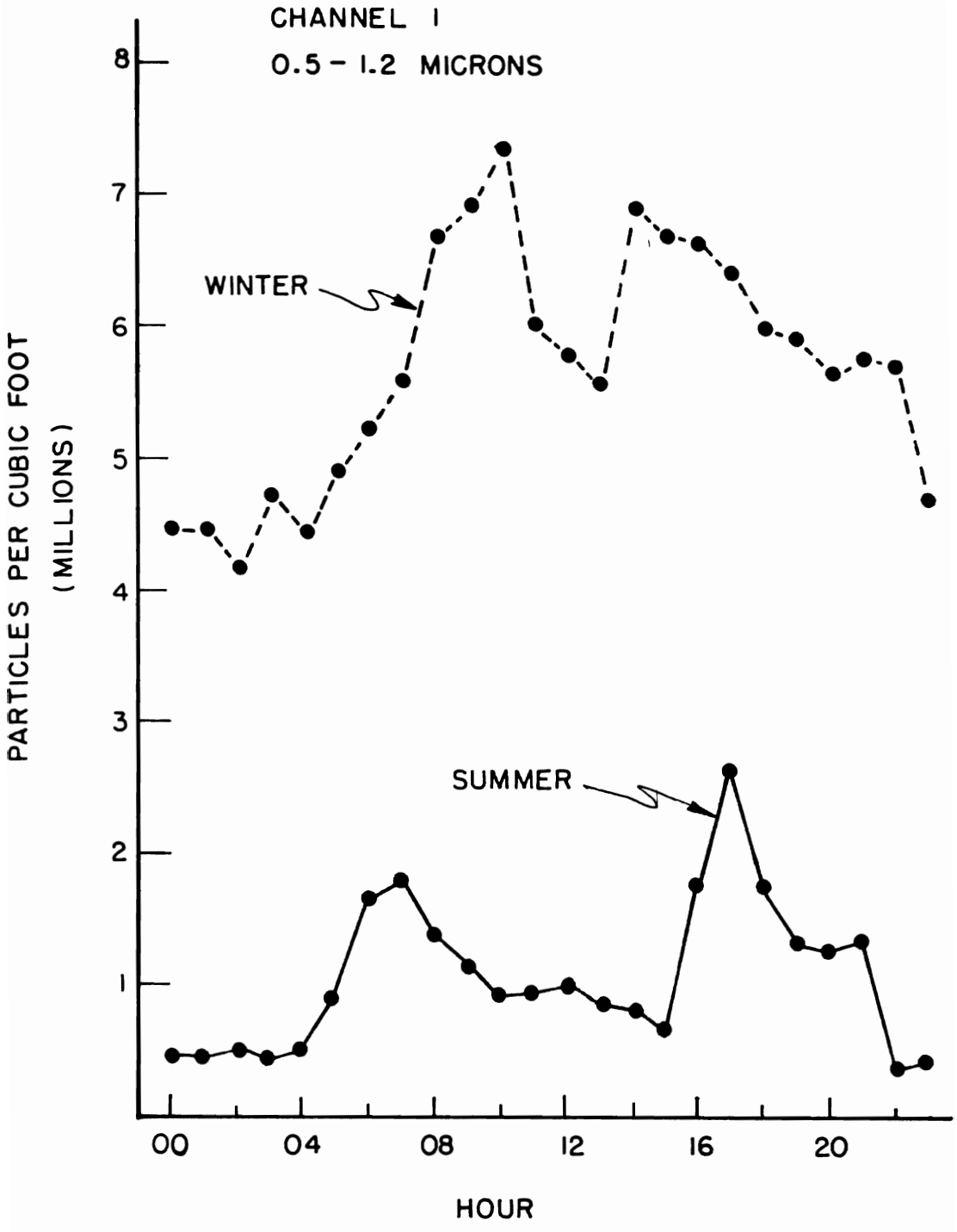

Figure 1. Hourly average winter and summer concentrations of particles from 0.5 to 1.2 microns in size.

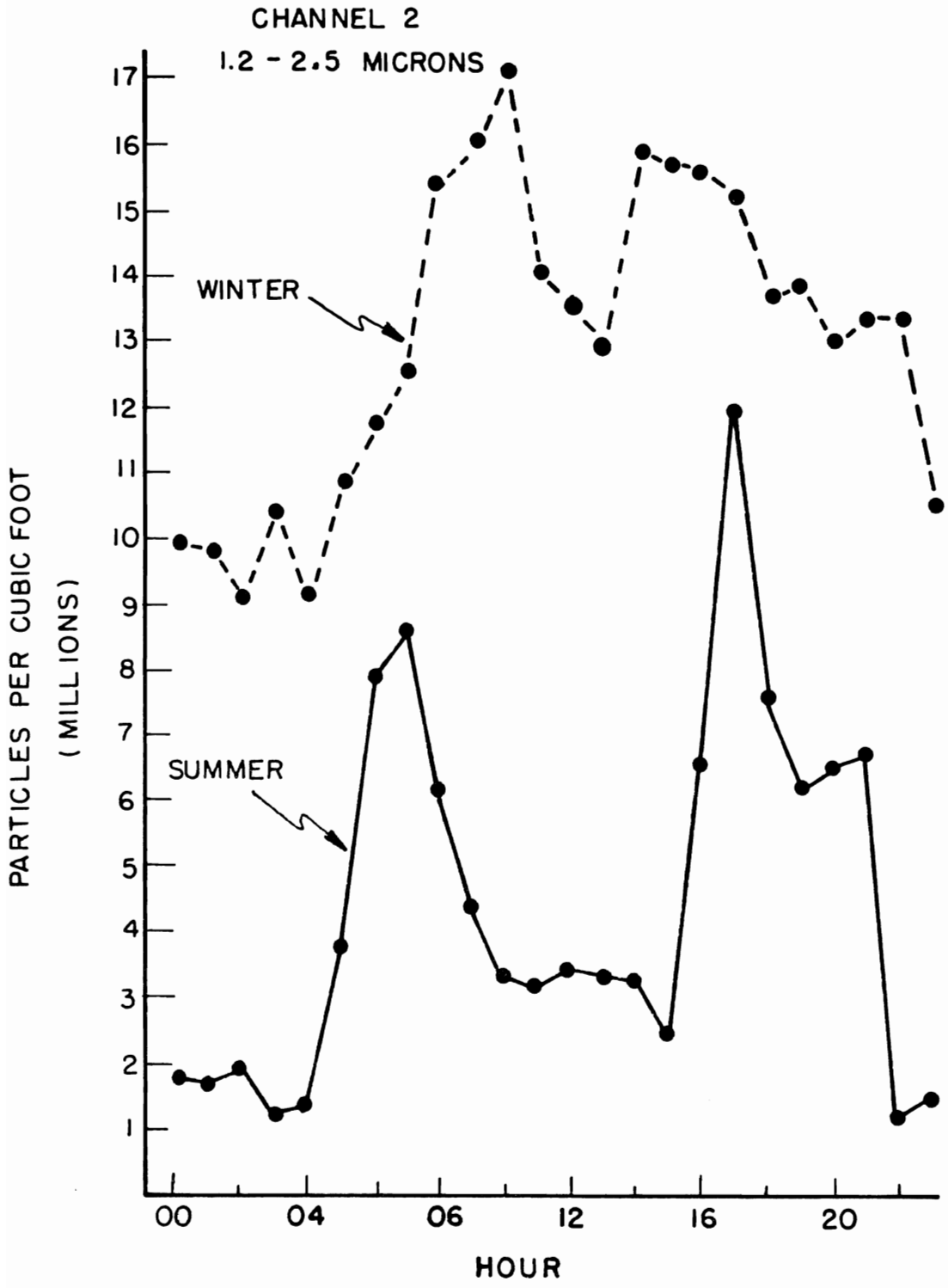

Figure 2. Hourly average winter and summer concentrations of particles from 1.2 to 2.5 microns in size.

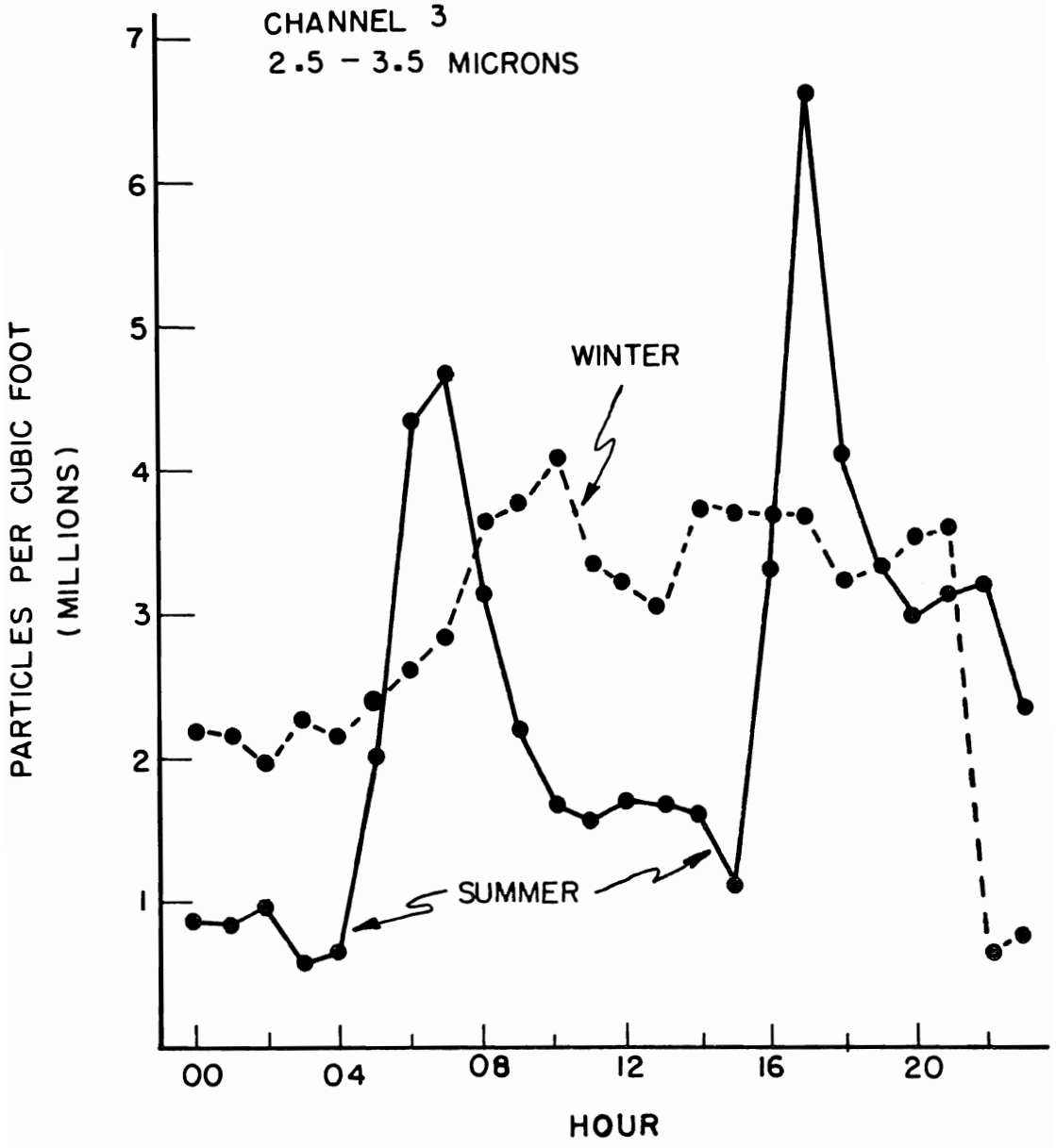

Figure 3. Hourly average winter and summer concentrations of particles from 2.5 - 3.5 microns in size.

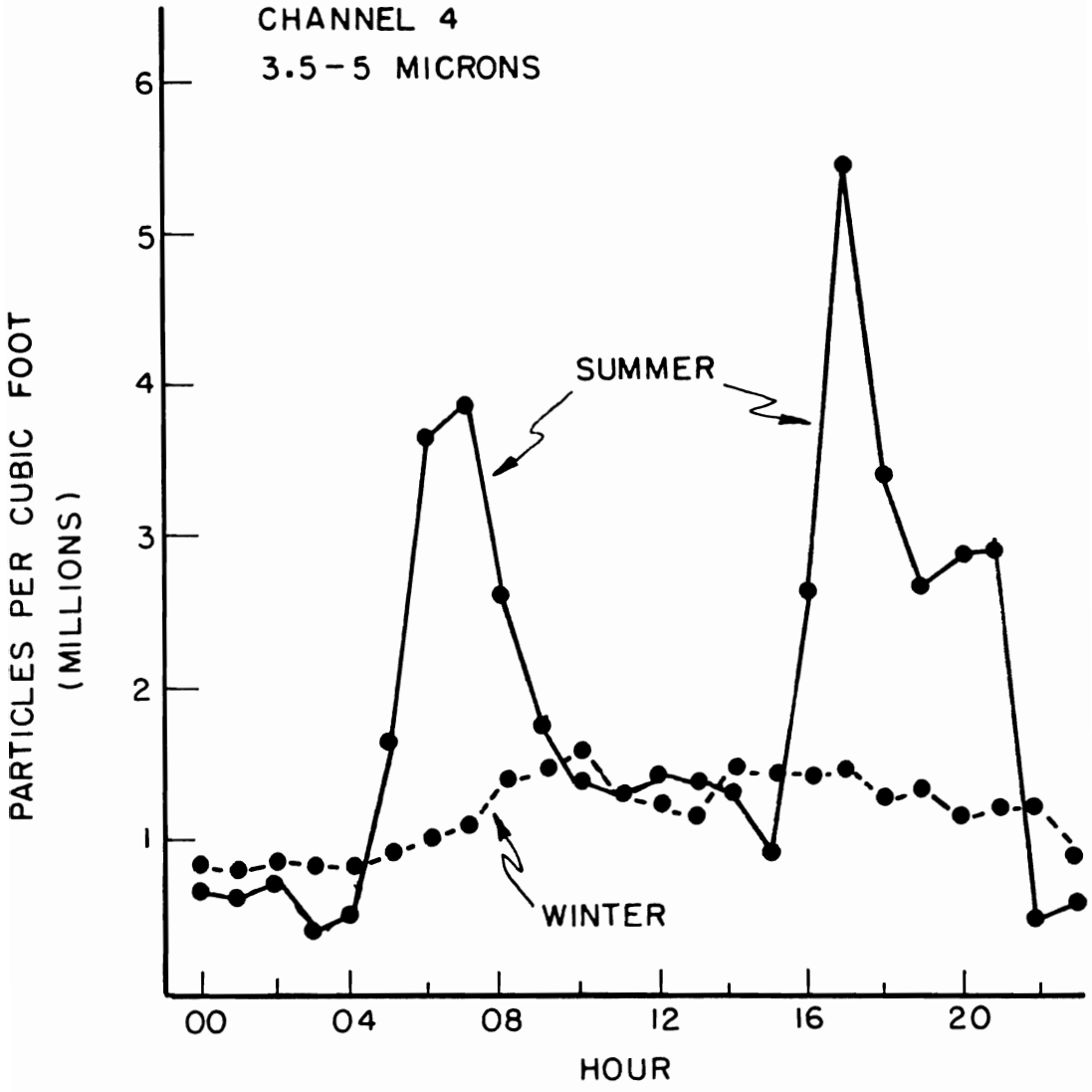

Figure 4. Hourly average winter and summer concentrations of particles from 2.5 - 3.5 microns in size.

A COMPUTER PROGRAM TO REDUCE DOWNGRADES IN TURKEYS

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Downgrades represent a considerable loss both to the whole bird market and also the reduction in market value of further processed products. Downgrades also indirectly increase the cost/lb of processing by causing line slowdowns and trimming costs. Average grade A for hens, toms and fryer roasters in the US (1982) was 84.3, 73.3 and 75.8%, respectively. Pinpointing the cause of these downgrades has many times remained an art rather than a science. Many factors usually interact in each flock making the identification of a specific cause difficult to identify. A method to elucidate the cause of downgrades is invaluable when we realize that downgrades can mean a loss of up to 7¢/lb.

A computerized system that utilizes data already collected by the company plus other valuable observations has proven to be a very good method to identify causes of downgrades. This system was first developed with broilers and then tailored to serve the needs of the integrated turkey companies in Virginia. Our purposes were three fold: First, to verify the data collected; 2) to identify the downgrade factors that show the greatest potential for improvement, and last, to determine what production, live-haul and/or processing procedures contribute to the problem and how to correct them.

Data collection for determination of downgrades is taken after inspection and prior to chilling. A 100 bird sample for every 5,000 birds in a turkey flock is used as the sample size. Information on each flock is collected by live production, live-haul, and processing plant personnel. Live production collects data on independent variables such as litter conditions, house temperatures, bird density, light intensity, dust levels, feed conversion, etc. for each flock marketed. Live-haul records the elapsed time between catch and processing, live-haul DOA's, number of birds per cage, etc. for the same flock. Specific downgrade information (dependent variables), such as breast blisters, breast bruises, leg bruises, wing bruises, cuts and tears, missing v-wings, missing whole-wings, missing drums, missing whole legs, condemned whole bird, and condemned parts are collected by the processing plant as well as independent variables such as trucking DOA's, bleed time, stunner setting, scald temperature, line speed, contamination evaluation, live weight, etc.

After collection, all data are submitted on a flock basis and analyzed. Printouts provide the company with means, standard deviations, minimum value , maximum value and simple correlations for all variables for the current month and for the composite (annual). Table 1 gives a sample output.

Table 1. Grade report giving means for the current month and the composite (recent 12 month mean).

		Current	12 months
1.	Grade A (%)	85.00	79.20
2.	Scabby hips (%)	10.60	11.90
3.	Feed withdrawal (hrs)	17.80	18.30
4.	Catch to processing time (hrs)	11.80	11.40
5.	Stunner setting	42.80	39.40
6.	Litter conditions-GO (1-3)	2.08	2.14
7.	Breast blisters (%)	(inc) 2.70	1.51
8.	Wing bruises (%)	(dec) 5.28	7.34
9.	Missing v-wing (%)	(inc) 3.44	3.01
10.	Condemnations - WB (%)	1.20	0.88
11.	Loadout DOA (%)	0.03	0.07
12.	Plant DOA (%)	0.16	0.32

Sample correlation data is also given in Table 2 for Grade A. Correlation coefficients statistically give a relationship between two variables. Values can vary between +1.0 and -1.0. A relationship of +1.0 would indicate that as one variable increased the compared variable also increased at the same rate. A negative coefficient -1.0 indicates an inverse relationship; i.e., as one variable increases the compared variable decreases. For example, bruises and Grade A, r = -.45, and weight and market age, r = +.65. No relationship is indicated as "r" approaches zero. Data can also be listed to provide rankings by growers according to a particular downgrade problem; i.e., breast blisters, total bruises, or percent Grade A.

Table 2. Some typical correlation coefficients (r) for Grade A. (Y = Grade A)

Independent variables	Current	12 months
Catch to hang time	-.64**	-.18**
Wilder birds	NS	-.12*
Drive score	-.24*	-.17**
Age	-.53**	-.34**
Weight	-.46**	-.25**
Litter	NS	+.18**

*≥ significant at .05 level.
**≥ significant at .01 level.

Correlations allow for statistical evaluation to compare the effect of certain practices (independent variables) on grade (dependent variables); i.e.; stunner setting's effect on bruises, or feed type on yield or feed conversion. Summaries of the information are developed to aid a monthly problem solving session that involves live production, live-haul, processing and management personnel.

The discussion of common problems across a table helps in eliminating "finger pointing" in different sections of the company and develops cooperation for solving problems. After a data base is built up, decisions can be made to initiate changes for a certain production or processing practice. In future meetings, all changes are reviewed to determine whether positive progress has been made.

General observations that have been made concerning the program are:

1. Seasonal influence on such variables as breast blisters (June-Sept) can be studied and solutions concentrated on to diminish the effects on grade A.

2. Time interval from feed withdrawal to catch can be plotted to find optimal time. Also, the effect of feed withdrawal on crop fullness and intestinal contamination can be studied.

3. Scheduling of birds for processing has shown to improve Grade A.

4. Holding toms on the truck for longer than 16 hours causes increases in missing parts, cuts and tears and intestinal contamination.

5. Listing data to compare live-haul crews, servicemen, and individual grower performance provides management with valuable information to use when making decisions.

6. Inspector or inspection competence can be evaluated.

7. Grade A can be increased by identifying and concentrating on individual problems with progress recorded by the program.

8. Cost is minimal to assemble data.

This program has proved to be a successful effort that involves industry and state resources to solve production problems. The information gathered remains confidential and for use only by the individual company. This same program could be beneficial in most cases whether grade is a significant problem or in use as just a quality control program.

COMPUTER SIMULATION FOR TURKEY PRODUCTION, WITH EMPHASIS ON NUTRITION, ENVIRONMENT, AND PROFITABILITY

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In turkey production there are two facts which no one seems to dispute. One is that profit margins are often extremely slim and the other is that feed comprises about 70% of the total cost of production. A thought pulling these two observations together is that if feed cost can be reduced the savings can be moved into the profit margin. For example, if one could feed the equivalent of 1% less protein throughout the life of a turkey consuming 75 pounds of feed one would save 9 cents per bird (presuming corn at $5.00/100 pounds and soybean meal at $10.00/100 pounds). This shows how a small change in feed formulation can affect net returns. There are many possibilities to tailor the feeding program to conditions.

To take advantage of such savings one must have a good understanding of the nutritional requirements and of nutrition/performance input:output relationships so that the nutritional program may be varied in anticipation of specific production situations.

The micro-computer offers the possibility for the family turkey enterprise to examine such efficiency relationships. This new opportunity utilizes the computer to simulate varying production options and make direct comparisons as to which option may be more profitable.

ALTERNATIVE STRATEGIES

The commercial production of a turkey is composed of the integration of many production compartments. For example, having set the specifications for a nutritional program, the least cost solution for the diet represents an optimization of the ration for the nutrient and ingredient levels specified. Another compartment may be physical floor space and feeder and waterer distribution: growth and well-being are dependent on physical space and services. Another compartment may include environmental temperature: feed intake varies with environmental temperature as does growth. Another may be disease control. Another may be selection of breeding stock from a hatchery where good management has produced healthy poults. Success in production is related to the integration of the various compartments such that the net production of the bird is optimum and at lowest cost. Less successful producers may give special attention to some compartments but may have not given balanced attention to all. Good producers may not be able to take advantage of all the indicators which are important due to the complicated interrelationships involved.

The foregoing serves to introduce the subject of what a simulation program can do. It takes into account all expense items and expected performance and mimics actual production. By performing repeated simulations, it enables one to quantitate the expected production characteristics of reference and comparison flocks by considering alternative options available at the time.

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Examples of testing alternative strategies (or options) may be mentioned. The program in use should be considered as the basis for comparison. The projected results may then be compared with results from alternative combinations of inputs and outputs so that total production system profitabilities may be identified.

Example 1. Suppose the price of soybean meal increases from $9.00 to $15.00 per 100 lb. The first alternative strategy would be to determine if other protein sources may be used in an equivalent nutritional sense. Before long, one would observe that these protein sources increase in price about the same as soybean meal. The next alternative strategy might be to ask the question, "What happens if I decrease my dietary protein levels?" It is possible to formulate lower protein diets, assigning the higher soybean meal costs to both the base and the alternative programs. There is, however, an important manifestation of reduced protein level which must be considered. What happens to growth and performance under the alternative conditions? The simulation considers both the changed costs of the diets and the impact of altered performance upon profitablity.

Example 2. A producer has been using fairly low levels of dietary added fat in the reference program. However, the price of fat has been decreasing and it would be worthwhile to consider an alternative program which utilizes diets of higher fat levels. Again, not only do diet costs change with new diets, but performance may be expected to change. It is the role of the simulation to combine cost and performance changes in aiding the user to an understanding of lower cost possibilities.

Example 3. There are many practices that a producer must decide upon from time to time, e.g. pelleting and addition of dietary antibiotics. If one can quantitate the expected costs and advantages of the practice, one may through simulation determine whether the practice will be beneficial by observing effects on net returns.

Example 4. This is a non-dietary example. The simulation calculates results on a daily basis, and can provide information on the optimum time to market the birds in terms of net returns on both a per flock and a per year basis. The latter is more important to a producer utilizing facilities throughout the year as the time required to produce a given flock will influence the number of flocks per year. If a producer has only two flocks per season, probably grown out on range, it may not be so important how long it takes to produce a flock. It is just a matter of waiting a little longer to produce the size birds desired.

DESCRIBING THE SIMULATION

The starting point (basis) of the simulation is the expected growth curve of the turkeys. Each turkey grower may have an expected growth curve or use a standard growth curve such as published yearly in Turkey World. The growth curve is presented on a weekly basis. If the producer knows only what final weight is expected, the curve may be calculated by pro-rating against the standard growth curve. An important feature of the growth curve in the simulation is that it may be modified by two kinds of conditions: intrinsic and extrinsic. Intrinsic conditions are defined as those associated with the physical environment of the bird. If temperature is expected to be high during the production period one would need to reduce the expected growth rate. Another intrinsic

factor which affects growth rate is floor space and feeder and water services. Extrinsic factors are defined as those from outside the bird in its production situation, provided mainly through the feeding program. One may reduce growth rate if a low protein or low energy diet is provided or increase growth rate if pelleting or antibiotics are being considered.

The environmental temperature is used in the simulation in a number of ways. An important one is that the feeding schedule can be adjusted to environment either on a time of change basis or on a quantity of feed basis. This is done by considering the deviation of the expected environmental temperature from a moderate environmental temperature. Another effect of environmental temperature is its influence on growth. Environmental temperature also influences feed intake. The program calculates feed intake, which depends on body tissue deposition and energy required for heat.

The simulation does not formulate diets but accepts information from diet programs. The nutritionist provides the diet information. The time of change for each successive diet for males and females is provided, as is the diet's metabolizable energy and lysine contents, and cost. If diet composition calculations are needed, an optional pre-calculation mode is included in the program which enables the user to calculate dietary information and enter the information directly into the system. If a producer is using a base mix, corn, and soybean meal, the calculation mode would include just these three ingredients. It would be necessary in this case to secure metabolizable energy and lysine contents of the base mix from the nutritional supplier.

There are two feed intake modifiers, one entitled "efficiency" and the other "adjustment." The efficiency modifier allows the user to alter feed efficiency on a weekly basis according to expected changes due to such factors as pelleting or feed wastage. The adjustment modifier allows the user to adjust feed intake if it is believed that the feed intake calculated by the program does not fit the intended farm situation.

Another input section for the program involves production details, such as flock size, percentages of grade A and B turkeys, target weight, and expected selling price. Also included are fixed and variable costs for the production unit.

RESULTS SUMMARIES

Five summary tables are identitified as feeding schedule, individual production data, flock production data, various costs, and net returns on an individual bird and flock basis. All output tables excepting the feeding schedule are presented on a daily basis. These tables may be viewed on the computer monitor screen, they may be printed, and/or selected portions of the data may be placed in file for problem comparisons using either tables or graphics.

AVAILABILITY OF PROGRAM

It is planned to have a demonstration of the program at the turkey research meeting associated with these Proceedings. Upon completion, the program will be distributed through EXTEND of the Agricultural Extension Service, University of Minnesota. Under this activity, the program will be placed in counties and be available to use on county microcomputers under the direction of the County

Agent. For those wishing to use the program on their own microcomputer, it will be available for a fee.

A portion of the fees will be utilized to meet costs associated with the development of this and other programs. The remainder will be used for turkey research. Clearly the alternative strategy approach is dependent on the availability of accurate research information. The funding developed by the simulation will support studies on alternative feedstuffs, nutrient compositon and availability, environment interactions, and quality of market turkeys produced.

Nutrition researchers have long recognized the shortage of research data and the need for more experimentation to quantitate the many variables. Too many have concluded that nutrition is "in the bag." It is important to support the concept that the feeding program represents a prime opportunity for reducing production costs and improving product quality.

This simulation program is dedicated to the twin concepts that efficiency of quality turkey production is paramount and that research with healthy animals can provide data necessary to achieve this goal.

MANAGEMENT AS IT RELATES TO FEEDING OF MARKET TOMS

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Turkeys raised on intermittent light have a slightly different growth pattern than turkeys raised on a continuous light of 12 to 16 hours. The poults grow slower early in life and faster later in life. This may have an effect on the nutrient requirements to produce maximum growth. An experiment was set up to determine a better method of managing the feeding program.

Dunkelgod, 1981, demonstrated that turkeys raised on feeds of higher nutrient densities in their diet grew faster.

Ewing, 1963, lists the calorie protein ratio for growing market turkeys as shown in table 1.

Table 1. Protein requirements of turkeys expressed as Calories for each 1 percent of protein.

Age	Energy level	Protein %	Calorie/Protein Ratio
0 - 7	1250	28	45
7 - 12	1320	22	60
12 - 18	1350	18	75
18 - Market	1360	16	85

Scott, 1984, lists the protein and energy requirements as shown in table 2.

Table 2. Relation of Protein Requirements to Dietary Energy Levels and Age of Turkeys.

Metabolizable Energy Kcal/lb.	Starter 0-4 wks % Protein	Grower #1 4-12 wks % Protein	Grower #2 12-18 wks % Protein
1200	28	22	16.5
1250	29	23	17.0
1300	30	24	18.0
1350	31	25	18.5
1400	32	26	19.0

If the calorie protein ratio is calculated from Scott's table for grower #2, it is approximately 73 calories per 1 percent of protein. This is maintained regardless of the energy in the feed. Thus as energy is increased protein and other nutrients must also be increased.

METHODS

Two thousand Nicholas large white toms were brooded with intermittent dim light of 0.4 foot candles (15 watt bulbs in the ceiling). They were fed a low energy feed containing 400 pounds of pulverized oats per ton of feed as a replacement for corn, for the first 1 pound of feed given each tom. This feed is used only the first 3 weeks. Low energy feed, dim lights, and adequate feed and water spaces produces a uniform bird with a strong immune system. The only medication used is a coccidiostat in the starter feed. No other medication has been necessary. Each building is cleaned and disinfected once a year. Cleaning is done in the spring. Old litter generates heat so fresh litter is used going into the hot summer months. Four to five flocks are brooded and reared on the same litter. Manure accumulations around the feeders and waterers are removed on a routine basis keeping the litter in good condition.

Controlling the environment for confinement growing of turkeys is very important. If growth can be increased by good environment, will this effect nutritional requirements? This experiment attempted to look at the effects of feeding more protein in the rearing barn than is generally done on commercial flocks. Protein sources are expensive sources of feed ingredients and certainly should not be fed in excess. On the other hand protein needs to be adequate to maximize growth.

From a management point of view it is very important to properly manage a feeding program. The interest in the utilization of fat to improve feed efficiency by commercial growers resulted in the over-looking of the importance of protein as fat is increased in the diet.

A trial was set up to test the effect of increasing the protein 3% with 4% added fat to a diet after 8 weeks of age.

RESULTS

Based on 4 week feed consumption periods, protein was consumed as follows in the rearing barn: The Conventional protein group consumed 2.82, 5.49 and 3.77 pounds of protein for 8 to 12, 12 to 16 and 16 to 20 week periods respectively per tom. The group given 3% higher protein feed with 4% added fat consumed 4.25, 6.36, and 4.03 pounds of protein for the periods 8 to 12 weeks, 12 to 16 weeks, and 16 to 20 weeks respectively per tom.

The birds on the lower protein weighed 26.85 pounds at 20 weeks with a feed efficiency of 3.1 pounds of feed per pound of gain. The toms on the higher protein weighed 28.32 pounds with a feed efficiency of 2.88 pounds of feed per pound of gain. Using the current prices for corn, soybean meal, and fat at the time of writing, the feed cost was 50 cents more per tom on the high protein 4% fat diet. But the extra weight of 1.47 pounds more per tom increased the income by 58.8 cents per tom. This leaves a profit of 8.8 cents per tom in favor of the higher protein feed.

As one increased the fat in growing and finishing feeds it is important to be sure that the daily consumption of protein is adequate to sustain growth. It is the increase in growth that increases income.

The best way to determine the adequacy of the environment which includes feed and water space is to weigh 50 birds and determine the range in weight. If 80% or more of the birds weighed are within 10 percent of the average weight of the samples, then conditions are good. If only 50-60 of the weights are in this range then there is inadequate feeder and water space or other environmental conditions that are poor. As further processing becomes more important uniformity of size will become very important. Lack of uniformity is caused by poor environmental conditions.

Good uniformity without maximum growth requires an evaluation of the feeding program being used. A good way to monitor a feeding program is to look at the daily rate of gain. A simple way is to weigh a sample of birds and calculate their average weight and divide that by their age in days. This figure should increase each week. If it levels off too early this is an indication the the turkeys are not getting the proper balance of nutrients.

The turkeys on this experiment were weighed every 4 weeks with the following daily rates of gain:

Table 3. Average daily rate of gain for Turkeys Reared on Different Levels of Protein and Fat.

Age Wk	Conventional Diet	3% added Protein + 4% Fat
4	.053	.053
8	.114	.114
12	.149	.169
16	.185	.191
20	.192	.202

SUMMARY

To get a measure of uniformity one should sample about 50 birds. This is the best method to measure a management program. Management and disease will affect weight. But it usually results in reducing the growth of some birds while the healthy aggressive birds continue to gain in weight. Flock uniformity is a good measurement of management skills. Rate of growth for all ages is a measure of fulfilling nutritional needs.

Intermittent light changes the activities of the turkey which requires less energy. Thus the calorie protein ratio of confined turkeys raised on intermittent light may require less energy for each 1 percent of protein in the diet during the rearing period. To maximize growth this adjustment should be made.

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THE EFFECTS OF WHITE LUPINE ON THE GROWTH, FEED EFFICIENCY AND TASTE CHARACTERISTICS OF TURKEYS

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INTRODUCTION

Providing optimum nutrition at a minimum cost is a primary objective of the nutritionist. One way this goal can be reached is to incorporate alternative feed ingredients into existing feeding programs. In southern Minnesota corn and soybean meal are often plentiful and provide reliable energy and protein for turkey diets. In some areas it may be impossible to grow corn and soybeans economically due to climate and soil conditions, so there is a need for alternative crops. A crop such as white lupine has potential in replacing part of the protein and energy normally provided by corn and soybean meal.

General information from Gladstones (1970) indicates the following. White lupine (Lupinus albus) is a pulse crop and member of the legume family of plants. Various species of lupine have been used as food for humans and livestock since ancient times. These early lupines were "bitter" because their alkaloid content could exceed 2.0%. Before bitter lupine could be fed, steeping in water was necessary to reduce its bitter taste and toxic alkaloid level. In the early 20th century, plant breeders in Germany developed "sweet" (low alkaloid) white lupine. White lupine can be grown in mildly acid loamy sand or loam soil that is well drained. It does well in cool to moderately warm climates and can be planted early due to tolerance to frost. Unlike soybean, white lupine does not require heat processing before feeding to remove trypsin inhibitors that interfere with protein digestion.

The nutrient composition of white lupine (Ultra variety) used in our turkey nutrition research is given in Table 1. The crude protein level ranged from 29.5 to 33.6%. Total sulfur amino acids are low for this moderately high protein level. Methionine and cystine levels of .33 to .34% and .52 to .61%, respectively, were determined for white lupine. The lysine level in white lupine is not as high as that in soybean meal protein, ranging from 1.59 to 1.75%. Determined crude fiber levels of whole white lupine meal have ranged from 9.8 to 11.6%, while the dehulled lupine meal contained 6.5% crude fiber. Calcium (.26-.40%) and phosphorus (.40-.57%) levels in white lupine are comparable to soybean meal. Metabolizable energy of the white lupine used was calculated by the formula of Carpenter and Clegg (1956). Values for whole white lupine ranged from 2827 to 2940 kcal/kg and for dehulled white lupine was 3208 kcal/kg.

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Few studies have been reported on the use of lupine in poultry diets. Yule and McBride (1976) observed that broilers fed diets containing up to 24% ground blue lupine seed (Lupinus angustifolius) grew as rapidly as those fed wheat-based diets when the diets were balanced for amino acids and energy. Shehata (1980) found that methionine supplementation improved the protein efficiency ratio of Lupinus termis in chicken broiler diets. Zaviezo and McGinnis (1980) reported that methionine supplementation resulted in significant improvements in growth and feed efficiency of chicks fed lupine based diets and that cooking dehulled lupine seeds and addition of penicillin provided growth responses.

MINNESOTA LUPINE STUDIES WITH TURKEYS

Previous studies reported from the University of Minnesota (Halvorson et al., 1983) indicated that commercially available whole ground white lupine (Lupinus albus) could be incorporated into diets of growing turkeys at low levels without significantly depressing growth. All studies utilized large white (Nicholas) commercial turkeys. Lupine was substituted into the corn-soybean meal diets holding methionine plus cystine and lysine constant in relation to metabolizable energy.

In the first study, 15% white lupine included in the diet of male turkeys during 0-3 weeks of age resulted in no change in growth rate, while 30, 45, or 60% white lupine resulted in growth that was depressed significantly and in proportion to level (Table 2). However, even at the 60% substitution level, growth was 85% of turkeys fed a corn-soybean meal control and the turkeys appeared to be normal.

The second study utilized female turkeys 8-12 weeks of age. White lupine was added to the corn-soybean meal control diet to replace 20, 30, 40, and 100% of the protein provided by soybean meal (Table 3). When white lupine protein replaced 20% of the soybean protein growth was 97.3% of control birds (non-significant depression). When 40% soybean protein was replaced, growth was 95% of control. Complete replacement of soybean protein resulted in growth that was 85% of the control birds. Inspection of internal organs at the end of the study revealed that as lupine level increased so did the empty gizzard weight and coarseness of the gizzard lining. It was speculated that a portion of the growth depression may have been due to the relatively high crude fiber level (nearly 12%) of the whole white lupine seeds.

A third study was conducted that investigated the effects of feeding dehulled white lupine on the growth rate of male turkeys during 4-21 days of age. Ground whole and dehulled white lupine were added to a corn-soybean meal type diet at both 20 and 40% levels. The corn-soy diet was fed to all birds during the 0-4 day pre-experimental period. Feeding either the whole or dehulled lupine at the 20% level produced growth and feed efficiency that was similar to the corn-soy control group (Table 4). When 40% whole lupine was included in the diet, body weights were significantly ($P<.05$) depressed (10.9% below control). When 40% dehulled lupine was added growth was down 4.7% from control but this depression was not significant. Feed efficiencies for all groups were similar except for the 40% whole lupine group which was significantly ($P<.05$) poorer than the rest. Dehulling the white lupine proved to be beneficial when it was included at the 40% level. At the 20% level, dehulling the lupine made no difference in growth rate or feed efficiency.

From these data it appears that the turkeys were able to tolerate the additional fiber brought into the diet by the 20% whole lupine. At the 40% level, dehulling the lupine reduced the calculated crude fiber level of the diet from 2.24% to 1.48%. This was apparently enough to reverse a large portion of the growth depression with 40% white lupine.

Full-term Market Study With Hens

In the fourth study graded levels of white lupine were included in the diets of market female turkeys, study duration 0-17 weeks of age, to examine the effects of prolonged feeding of lupine on growth, feed efficiency, and carcass quality. The following treatments were used: #1. corn-soy control, #2. soy to lupine ratio of 2:1, #3. soy to lupine ratio of 1:1, #4. soy to lupine ratio of 0.6:1. Table 5 gives partial composition of diets fed; as shown, the lupine levels decreased as the protein requirement of the turkey decreased.

The growth depressions caused by white lupine were most apparent during 0-11 weeks of age (Table 6). At 4 weeks, birds fed 18.9% white lupine had body weights lower, but not significantly lower, than the controls. Those birds fed 31.5 and 43.1% lupine were down significantly ($P<.05$) from the control group by 10.5 and 14.9%, respectively. At 8, 11 and 14 weeks of age the body weights of all birds fed lupine were significantly lower than the control group. At 17 weeks the body weights of birds in the 2:1 soy-lupine group were 1.9% less than those of the control group, but this was not significant.

Average daily gains (Table 7) of the lupine fed birds were also depressed from 0-11 weeks. From 11-14 weeks the 1:1 and 0.6:1 soy-lupine groups made recoveries in their gains. The birds being fed 18.2 and 25.0% lupine had significantly ($P<.05$) greater gains that were 6.5 and 7.0% above the control group, respectively. The feed efficiencies of the controls and all lupine groups were the same during 14-17 weeks.

Regarding feed efficiency (Table 8), during 0-11 weeks of age it was poorest with the two highest level groups. After 11 weeks, however, birds fed lupine were generally more efficient than the controls. The overall feed efficiency data (0-17 weeks) showed that all groups, except the highest lupine level, had similar feed efficiencies. The 0.6:1 soy-lupine birds had the poorest ($P<.05$) feed efficiency from 0-17 weeks.

A sensory (taste panel) evaluation of the meat from the hens was performed to determine if feeding of white lupine had effected any changes in taste characteristics. After termination of the experiment seven representative birds from each treatment group were sacrificed and processed at the University of Minnesota poultry abbatoir. Dark and light meat samples were taken from each bird, chilled for 24 hours, and then frozen. One week later the samples were thawed slowly and cooked to an internal temperature of 185°F.

Sensory evaluation panels were set up to distinguish taste differences between the treatment groups in both the light and dark meat. Fifty-five experienced tasters participated. Each taster ranked both light and dark meats on a scale of one to four, where: one was liked best and four was liked least.

Table 9 shows the final results from the sensory evaluation. No differences were found between treatments in the dark meat. A significant preference was found for light meat from birds in the control group and those fed the highest level of white lupine. The turkeys fed lupine in a one to one ratio with soybean meal were liked least. It is not clear why this would happen but it is safe to conclude that prolonged feeding of white lupine has no detrimental effect on the flavor of turkey meat.

CONCLUSIONS

1. The feeding of more than 15-20% of white lupine in diets of turkeys for 3-4 week periods resulted in minor growth depressions. This retardation tended to decrease as turkeys were fed lupine for longer periods; in fact, compensatory growth became evident after 11 weeks of feeding even though the lupine level was 25% of the diet.

2. Dehulling of the lupine, resulting in decreased dietary fiber content, reduced the extent of growth depression.

3. Feeding of white lupine to market hen turkeys during 0-17 weeks of age had no detrimental effect on the flavor of the light and dark meat.

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Table 1. Proximate analysis and amino acid composition of white lupine used in Minnesota turkey nutrition studies.

	Experiments 1 and 2	Experiment 3		Experiment 4
		Whole	Dehulled	
	----------%----------			
Moisture	12.6	14.1	11.8	13.4
Protein	32.0	29.5	33.6	29.9
Fiber	11.6	11.6	6.5	9.8
Fat	8.8	10.1	11.9	8.7
Calcium	.40	.32	.26	.36
Phosphorus	.41	.50	.57	.40
Total sugar (as invert)	3.6	5.4	5.7	
Starch	18.7	16.0	15.4	
Alanine	1.09	1.18	1.19	
Arginine	2.99	3.76	3.97	
Aspartic acid	3.38	3.51	3.62	
Glutamic acid	6.26	7.21	7.81	
Glycine	1.28	1.47	1.52	
Half cystine	.52	.58	.61	
Histidine	.71	.84	.90	
Isoleucine	1.52	1.59	1.71	
Leucine	2.33	2.68	2.83	
Lysine	1.59	1.74	1.75	
Methionine	.34	.33	.33	
Phenylalanine	1.19	1.42	1.50	
Serine	.88	1.43	1.56	
Threonine	.80	1.24	1.35	
Tyrosine	.98	1.49	1.65	
Valine	1.50	1.72	1.72	

Table 2. Performance of male turkeys fed white lupine from 0 to 3 weeks of age (Experiment 1).

Treatment[1]	Body weight (g) (3 weeks of age)	Feed/Gain (0-3 weeks of age)
Corn-soy (CS)	471[a]	1.48[b]
CS with 15% white lupine	480[a]	1.56[b]
CS with 30% white lupine	442[b]	1.56[b]
CS with 45% white lupine	419[bc]	1.70[a]
CS with 60% white lupine	400[c]	1.71[a]

[1]Six replicate pens of eight turkeys each were used per treatment.

[a,b,c]Means in columns with different superscripts are significantly different (P=.05).

Table 3. Performance of female turkeys fed white lupine from 8 to 12 weeks of age (Experiment 2).

Treatments[1]	Body weight (kg) (12 weeks of age)	Feed/Gain (8-12 weeks of age)
100% SBMP, 0% WLP[2]	4.44[a]	3.13[c]
80% SBMP, 20% WLP	4.38[ab]	3.18[bc]
70% SBMP, 30% WLP	4.30[b]	3.27[b]
60% SBMP, 40% WLP	4.32[b]	3.23[bc]
0% SBMP, 100% WLP	4.11[c]	3.49[a]

[1]Three replicate pens of ten turkeys were used per treatment. Average starting weight at 8 weeks was 2.25 kg.

[2]SBMP = Soybean meal protein, WLP = White lupine protein.

[a,b,c]Means in columns with different superscripts are significantly different (P=.05).

Table 4. Performance of male turkeys fed whole or dehulled white lupine from 4 to 21 days of age (Experiment 3).

Treatments[1]	Body weight (g) (21 days of age)	Feed/Gain (4-21 days of age)
Corn-soy (CS)	450[a]	1.48[c]
CS with 20% white lupine	448[a]	1.54[bc]
CS with 40% white lupine	401[b]	1.67[a]
CS with 20% dehulled white lupine	438[a]	1.55[bc]
CS with 40% dehulled white lupine	429[ab]	1.57[bc]

[1]Five replicate pens of eight turkeys each were used per treatment.

[a,b,c]Means in columns with different superscripts are significantly different (P=.05).

Table 5. Amounts of white lupine fed in Experiment 4.

Treatment	White lupine fed during periods, weeks				
	0-4	4-8	8-11	11-14	14-17
	----------%----------				
1. Corn-soy control[1]	-	-	-	-	-
2. Soy:Lupine = 2:1	18.9	16.5	14.0	10.9	8.1
3. Soy:Lupine = 1:1	31.5	27.6	23.5	18.2	13.6
4. Soy:Lupine = 0.6:1	43.1	37.8	32.2	25.0	18.7

[1]Control diet series was corn and soybean meal based diet with 4% added fat (Waibel, 1974).

Table 6. Body weights of female turkeys fed white lupine from 0 to 17 weeks of age (Experiment 4).

Treatments[1]	Body weight at week				
	4	8	11	14	17
	----------kg----------				
1. Corn-soy	.645[a]	2.29[a]	4.17[a]	5.76[a]	7.25[a]
2. Soy:Lupine = 2:1	.619[a]	2.19[b]	3.97[b]	5.57[b]	7.11[ab]
3. Soy:Lupine = 1:1	.574[b]	2.07[c]	3.77[c]	5.45[b]	6.99[b]
4. Soy:Lupine = 0.6:1	.551[b]	1.99[c]	3.73[c]	5.40[b]	6.93[b]

[1]Eight replicate pens of eight turkeys each were used per treatment.

[a,b,c]Means in columns with different superscripts are significantly different (P=.05).

Table 7. Average daily gain of female turkeys fed white lupine from 0 to 17 weeks of age (Experiment 4).

Treatments[1]	Average daily gain for weeks		
	0-11	11-14	14-17
	g		
1. Corn-soy	53.2[a]	74.3[b]	71.1
2. Soy:Lupine = 2:1	50.0[b]	74.3[b]	71.9
3. Soy:Lupine = 1:1	48.1[c]	79.1[a]	73.3
4. Soy:Lupine = 0.6:1	47.3[c]	79.5[a]	71.9

[1]Eight replicate pens of eight turkeys each were used per treatment.

[a,b,c]Means in columns with different superscripts are significantly different (P=.05).

Table 8. Feed efficiency of female turkeys fed white lupine from 0 to 17 weeks of age (Experiment 4).

Treatments[1]	Feed/gain for weeks			
	0-11	11-14	14-17	0-17
1. Corn-soy	2.13[b]	3.25[a]	3.75	2.70[b]
2. Soy:Lupine = 2:1	2.12[b]	3.18[ab]	3.68	2.67[b]
3. Soy:Lupine = 1:1	2.22[a]	3.09[b]	3.67	2.73[b]
4. Soy:Lupine = 0.6:1	2.29[a]	3.15[ab]	3.78	2.82[a]

[1]Eight replicate pens of eight turkeys each were used per treatment.

[a,b,c]Means in columns with different superscripts are significantly different (P=.05).

Table 9. Sensory evaluation of turkey meat from hens fed white lupine from 0-17 weeks of age (Experiment 4).

Treatments[1]	Average score[1]	
	Light meat	Dark meat
1. Corn-soy	2.33[b]	2.65
2. Soy:Lupine = 2:1	2.51[ab]	2.53
3. Soy:Lupine = 1:1	2.93[a]	2.51
4. Soy:Lupine = 0.6:1	2.24[b]	2.31

[1]Total rank sum divided by number of judges (N=55). Scoring based on a system where: 1 = Liked best ... 4 = Liked least.

[a,b,c]Means in columns with different superscripts are significantly different (P=.05).

SEMEN QUALITY AND ITS PRESERVATION

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The production of high quality semen is essential for the attainment and maintenance of high fertility. Semen quality varies both between and within sire. Variance between sires indicates an inherent ability or inability for semen quality production. Variance within sire may be the result of several factors which may include light, temperature, nutrition, general health or method, time and frequency of semen collection. Regardless of the origin and existence of either high or low quality semen, some method of its assay and selection is imperative for high fertility (Brown and Graham, 1971). Likewise, in recent years some emphasis in research has been placed on methods of extending semen for longer term storage and use (Sexton, 1979, 1980; Lake, 1981; and Graham et al., 1982). In this regard, selection for high quality semen again appears to be essential. Ansah and Buckland (1980), Borsting (1981).

The purpose of this presentation is to report on research conducted on 1) tom flock semen evaluation and relation to fertility, 2) individual tom differences in response to semen storage and relation to fertility and 3) effect of storage methods of selected semen on fertility.

Pre-season Semen Evaluation and Tom Selection

Methods and Materials:

Semen from a total of 502 medium White Wrolstad males was collected three times each prior to the breeding season at 3 and 4 day intervals. Semen was evaluated for volume, sperm numbers, percentage motility and percent cells capable of swelling without rupture after exposure to a hypotonic solution. Both percentage of motile sperm and swelling were assayed after the semen had been diluted 1 part semen to 2 parts MTGA buffer and stored at 5°C for 6-8 hours. Percentage motility was assayed by three independent technicians using closed circuit television. Sperm numbers were assayed spectrophotometrically. Percent swelling was assayed by use of an Elzone Counter.

After assay the birds were divided into four groups according to semen quality a) high, b) medium, c) low, and d) poor. Approximately 600, 1200 and 600 females were inseminated with toms from groups a, b, c weekly over a 14-week period. Fertility data was based on 10 day candle.

Results and Discussion:

The data obtained from 1506 samples of preseason collected semen is shown in Table 1.

The data shows a significant positive correlation between sperm numbers, percent motile sperm and sperm capable of swelling. A small but significant negative correlation was shown on semen volume. A highly significant difference in fertility was shown between semen quality and fertility. These data indicate that differences do exist between toms and that selection can be made. These data are in agreement with the previous findings of Brown and Graham (1971), which resulted in a 14% difference between high and low groups. The question arises as to whether all toms produce similar semen throughout the season. A further study was designed to test the repeatability of semen quality.

Repeatability of Production of Semen Quality

Methods and Materials:

Semen was collected from individual toms four times at 2 week intervals starting 2 weeks after start of production. Volume of semen was measured. Semen was then diluted 1 part semen to 4 parts buffer, cooled and transported to the laboratory for further analysis. All samples were examined for motility using the criterion of swirling action 6, 12 and 24 hours after collection. Not until after the six hour assay was the semen subjected to dialysis. This resulted in extra stress to the spermatozoa. Sperm cell numbers analysis was conducted and results were calculated to the original raw semen.

Results and Discussion:

Results indicate that only a percentage of birds produce semen capable of long term storage (Table 2). The lower percentage of birds (20-35%) showing higher quality semen at 24 hours storage is lower than previously (60%) reported. In all probability this discrepancy is due to improper handling during the first six hours. Nevertheless the data indicates large differences between birds and between flocks. Likewise, a high repeatability coefficient was shown indicating that the same birds produce similar quality semen on each collection.

The Use of Pre-selected Semen on Fertility

In an attempt to relate the effects of semen quality for fertility, a study was designed.

Methods and Materials:

Six lots of 12 females were randomly assigned. Two lots of males were used. One lot was unselected for semen quality. The second lot was unselected but semen to be used was selected from within this lot. For selected semen, only semen that displayed a swirling action at 24 hours storage was used. After collection the nonselected semen was pooled, diluted 1:3 with buffer, cooled and dialyzed against buffer for the 24 hour storage period. Two lots of females were inseminated with

nonselected semen after 20 minutes storage. This served as a control. The remaining 4 lots of females were inseminated with 24 hour stored semen from 1) selected semen, 2) nonselected semen, 3) selected semen 80% and 20% nonselected, and 4) 60% selected and 40% nonselected semen. Insemination was administered on day 0-3-8 and at weekly intervals over an 8 week period.

Results and Discussion:

The data (Table 3) reveals that the selection procedure is a viable test assay and that semen can be selected and influence fertility. Little difference (90.0 vs 92) was shown between selected and nonselected semen when insemination is carried out immediately after collection. After 24 hours of storage, selected semen resulted in 89% fertility and nonselected semen resulted in 71% fertility. The difference is statistically significant. Also shown is that an increase in fertility results when selected semen is added to nonselected semen.

Development of Techniques for Longer Term Storage of Turkey Spermatozoa:

Having established that assay turkey semen by maintenance of a swirl(s) is a viable process, using an appropriate buffer, simplified alternative storage methods were investigated. Our data has also continuously suggested that the higher the dilution ratio the longer the cells lived. Likewise known is that turkey spermatozoa requires oxygen for long term maintenance. Results of a typical study illustrating the above is shown in Table 4.

Methods and Materials:

Semen was collected from selected males and diluted 1:1, 1:2 and 1:3 and cooled to 5°C. The samples were split into 3 groups: 1) small vials and capped, 2) placed in dialyzing bags and dialyzed against buffer, and 3) placed in an open vial with 2x surface to volume ratio. The latter was placed in a dessicator at 5°C and pure oxygen was blown in replacing the air. The vessel was semi-sealed. Samples were checked for motility at 0, 6, 12, 24, 36 and 48 hours.

Results and Discussion:

As shown by the data, a significant difference existed between dilution ratios with the higher the dilution ratio the longer the samples survived. An overall difference was shown. Both treated samples were superior to no treatment. No significant difference was shown between dialyzed and O_2 treated semen.

In view of this finding, and as O_2 treatment is more simple and usable technique than dialysis, a fertility trial was set up to test dilution ratio and the 2 methods of storage.

Methods and Materials:

Semen was collected from selected males and diluted 1:1 and 1:3. The samples were cooled to 5°C and either dialyzed or stored under O_2. Six females in 4 lots were inseminated with equal sperm cell numbers (by adjusting volume/insemination) at 7 day intervals over a 14 week period. Semen was stored only for 6-8 hours prior to insemination. The data is presented in Table 5.

Result and Discussion:

The results show a small but significant difference between dilution ratios with the higher dilution ratio resulting in higher fertility (Table 5). Keep in mind, however, that equal total numbers of cells were inseminated by adjusting the volume of inseminate. The results possibly mean that the high dilution ratio maintained a greater percentage of live cells. The most encouraging result was that simplified method of storage under O_2 resulted in similar fertility to dialyzed storage.

Summary and Conclusion:

Individual tom selection for semen quality is possible using simple techniques of assay.

Individual toms have fairly consistent semen quality and can effectively be preseason selected.

A more precise selection procedure is to collect individual toms, assay and pool the high quality semen.

Selected semen for quality effects fertility.

Longer term storage of turkey semen is possible if selected semen is used.

Either dialysis of semen or storage under oxygen prolongs the useful life of spermatozoa.

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Table 1. The effect of preselection of toms for semen quality on fertility (502 males).

	High	Medium	Low	Poor
Sperm no./ml x 10^9	14.3	14.1	11.3	9.6
Volume, ml	.185	.189	.230	.245
Motility (6 hr), %	65.0	54.6	35.8	20.0
Sperm swelling, %	72.5	68.3	61.0	58.0
% Birds	22	43	21.0	14
Fertility*, %	89.7	87.1	81.0	

Semen dilution -- 1:2 (semen to buffer)
7 day insemination interval
1/30 ml per insemination
*High, Medium and Low fertility percent was based on 31500, 61000 and 30250 eggs, respectively.

Table 2: Sampling[1] semen quality from random birds in four flocks

Flock	No. Birds	$\bar{X}$ Vol.	$\bar{X}$ x 10^9 SP./ML.	% Samples S*	24 Hrs	% Samples S	12 Hrs	% Samples S	6 Hrs	r**
A	20	.21	10.3	(7)	35	(12)	60	(14)	70	.94
B	60	.37	6.1	(14)	23	(22)	37	(30)	50	.72
C	60	.31	6.8	(12)	20	(28)	47	(34)	57	.86
D	88	.29	7.4	(28)	32	(48)	54	(63)	71	.84

Sampling[1] -- Same birds sampled 4 times at 2 week intervals commencing 2 weeks after start of production.
S* -- Number ( ) and % samples showing swirling action.
r** -- Repeatability, % time that all samples responded the same, dilution 1:3, dialyzed after 6 hours, stored at 5°C.

Table 3: The effect of semen quality on fertility of semen stored for 24 hours.

	Nonselected Semen		Selected* Semen		Selected -- 4 parts Nonselected- 1 part		Selected -- 3 parts Nonselected- 2 parts	
	No. Eggs	% Fert.***	No. Eggs	% Fert.	No. Eggs	% Fert.	No. Eggs	% Fert.
Control, 20 min.	360	90.0	352	92.0	--	--	--	--
24 hr. stored**	342	71.6	372	89.0	366	81.0	374	74.0

12 birds/lot, 8 week duration, weekly insemination, 1/20 ml.
Selected* -- Swirl action of semen at 24 hours.
24 hr. stored -- Semen diluted 1:3 dialyzed, 5°C.
% Fert.*** -- Fertility based on 8-10 day candle.

Table 4. Effect of dilution ratio and motility of buffered semen (selected males) under three different storage conditions.

Dilution Ratio	0 hr.	6 hr.	12 hr.	18 hr.	24 hr.	36 hr.	48 hr.
			---- Storage 5°C ----				
1:1	S*	55	45	40	20	0	0
1:2	S	S	55	50	30	10	0
1:3	S	S	S	60	50	40	5
			---- Dialyzed (Ratio 1:10) ----				
1:1	S	S	S	60	50	-20	0
1:2	S	S	S	S	S	55	10
1:3	S	S	S	S	S	S	50
			---- Under appropriate O_2 (No dialysis) ----				
1:1	S	S	55	30	10	5	0
1:2	S	S	S	S	60	40	0
1:3	S	S	S	S	S	S	55

*S - Swirling motility
Significant difference between dilution ratios on time.
Significant difference between no treatment and treatments.
No significant difference between dialysis and O_2.

Possible storage for 36 hours at 1:3 dilution.

Table 5. Comparison of 2 types of storage methods and dilution ratio of fertility of turkey spermatozoa.

	No. Eggs	No. Fert.	% Fert.
		---- Dialysis ----	
1:1	294	(269)	88
1:3	312	(284)	91
		---- O_2 Method ----	
1:1	310	(269)	87
1:3	305	(276)	90

Selected toms
Six birds per treatment
14 week lay
Insemination 7 day intervals

Equal sperm numbers/insemination dosage approximately 100×10^6

6-8 hour storage + 5°C

EFFECT OF DIETARY PROTEIN AND LYSINE LEVELS, AND NEST CHARACTERISTICS ON TURKEY BREEDER HEN PERFORMANCE

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INTRODUCTION

A review of protein requirement studies for turkey breeder hens indicated that protein levels of 10 to 15% were sufficient for maximum egg production (Waibel and Noll, 1984). However, the requirement is much less variable when expressed on a daily intake basis as indicated by Wilgus (1976) who estimated a minimum daily requirement of 26-27 g/hen. The review also indicated that more protein was needed to maximize egg weight as compared to meeting the requirement for egg production.

With the anticipated increase in commercial availability of methionine and lysine supplements, research is needed to determine dietary amino acid needs so that these supplements can be used at effective levels and allow a reduction in dietary protein. Studies are reported herein on the lysine requirement and performance of hens fed low protein diets supplemented with lysine to the requirement level.

Previous studies have shown that the pen environment (floor vs. cage) can greatly affect egg production (Waibel et al., 1975) and broodiness (El Halawani et al., 1984). It was expected that the type of nest may affect egg production, broodiness, and the amount of labor needed for egg collection and nest care. Several nest types were tested as part of a factorial design with the above nutrition treatments. Full-trap nests had been used in previous studies but are very labor intensive in that training of hens and frequent egg gathering is required. The nests have an important advantage in research of allowing notation of individual hen data such as egg production, broodiness and production outages. To reduce the labor load, ideally, a nest is needed which is readily used by the hen and produces eggs suitable for hatching. In a series of experiments, semi-trap and community nests were examined as possible substitutes. An additional variable in the two experiments was the use of synthetic turf as replacement for shavings and in nests with a rollaway bottom.

MATERIALS AND METHODS

General

Large white (Nicholas) female line hens were light stimulated (15L:9D) at 30 weeks of age. They were kept in floor pens measuring 7x9 ft at the rate of 10 to 12 hens per pen and were inseminated with pooled semen from Nicholas male line toms every 10 days. Egg production records were kept from 33 to 53 weeks of age during which time the experimental diets were fed. Within each four week interval, eggs were collected and identified for determination of egg weight, fertility and hatchability. Hen body weights and feed intakes were also measured over the 20 week production period.

Lysine requirement studies

Two studies examined the response to supplemental lysine at differing protein levels using a corn-sesame meal diet. In Experiment 1 protein levels were 12 and 14%, while in Experiment 2 the levels were 11 and 14%. A control breeder diet based on corn and soybean meal was also fed in each study.

Amino acid supplementation of low protein diets

In two studies low protein diets based on corn and soybean meal were supplemented with lysine and methionine and their performance compared to control breeder diets. In the first study the low protein diet contained 10.5% protein and was fed without amino acid supplementation, with lysine supplementation and with both added lysine and methionine. The amino acid levels were based on the previously determined lysine requirement (.5%) and, for methionine, to the level of the control diet (.45%) which exceeded the NRC (1977) recommended level.

In the second study, a protein phase program was used where the dietary protein level is decreased but methionine and lysine supplementation is used to maintain those amino acid levels. In the phase program, hens were fed a 15% protein diet from 33 to 37 weeks, and a 12% protein diet (.03% methionine supplementation) from 37 to 45 weeks, and a 10.5% protein diet (.07% methionine and .14% lysine supplementation) from 45 to 53 weeks. The control group was fed a 15% protein diet from 33 to 53 weeks of age.

Nesting studies

Five experiments were conducted with Experiments 1 to 3 utilizing wood shavings for nesting material while the last two included comparisons of wood shavings to turf. Each pen contains a nesting box measuring 48" wide, 24" high, and 24" deep. In Experiment 1, for the semi-trap (SS), full trap (FS) and open (OS) nest types, this area is divided into 3 individual boxes with doors for the first two types and no door for the open nest. In the two community nest treatments (CS and CDS), one had sliding doors (CDS) which closed the nest area to the hens from 4 p.m. to 7 a.m. daily. In this first experiment no training program was used to get hens to lay in nests so as to determine if any nest type was more readily acceptable. In Experiments 2 and 3 the nest comparisons were SS and CS.

In Experiments 4 and 5 nesting material was also compared (wood shavings vs. turf). Some nests were modified to have a rollaway floor to facilitate egg collection where automation could be incorporated. In the fourth study the semi-trap nest type was used with shavings (SS) or with turf (ST) or with a rollaway floor with turf (STR). A community rollaway nest with turf (CTR) formed a fourth treatment. In Experiment 5 both the semi-trap and community nests were compared with shavings (SS, CS) or with a turf-rollaway bottom (STR, CTR).

RESULTS AND DISCUSSION

Lysine requirement studies

In the first experiment (Table 1) egg production was unaffected by lysine level (0.32-0.68%) at either 12 or 14% protein with respective lysine intakes ranging from .7 to 1.5 g/day. Lysine supplementation increased egg weight and reduced the amount of body weight loss over the 20 week period at both protein levels. Based on the responses obtained for egg weight and body weight maintenance, and the lack of response with egg production, .5% lysine was (1.19 g/day) adequate.

In the second study (Table 1) lysine supplementation of 11% or 14% protein diets increased egg production significantly with the greatest rate of production at the highest level of supplementation (.51% total lysine). Egg weight improved only in the 11% protein diets as lysine level increased. Body weight loss was minimal at .51% lysine. Daily lysine intakes averaged 1.10 g/day where lysine concentration was .51%.

Based on the results of the two studies, the requirement for lysine was estimated to be .51% (1.14 g/day) in diets containing 11, 12 or 14% protein and approximately 3230 kcal/kg of metabolizable energy. The experimentally determined requirement is less than the NRC (1977) recommendation of .6% and the Wilgus (1976) recommendation of 1.32 g/day.

Amino acid supplementation of low protein diets

In the first study (Table 2) the low protein diet (10.5%) depressed egg production, egg weight and feed consumption in comparison to the control. Supplementation with .15% lysine improved egg production significantly over the low protein group with no effect on egg weight. Supplementing with methionine (.07%) in addition to lysine improved egg weight slightly but not significantly. That the low protein diet supplemented with lysine and methionine supported equal egg production to the 15.7% protein control diet helped to substantiate the requirement estimate of .5% lysine. The low egg weight of the supplemented diets as compared to the control indicates that one or more amino acids may have been deficient in the low protein diet and were limiting egg weight but not egg production.

As the supplemented low protein diet resulted in low egg weight, it was hypothesized that perhaps the normal increase in egg weight during the breeder season could be delayed by feeding lower protein diets as the hens became older. To test this hypothesis the protein phase program was compared to a control group fed a 15% protein breeder diet for the 20 week period in the second study. No significant differences between diets (Table 3) were seen for egg production, fertility, and hatchability. Egg weight was reduced for the phase program by 2% with the difference between treatments becoming larger as the egg production season progessed. Contrary to the previous experiment, body weight loss over the 20 week period was greater ($p<.05$) for the phase-fed hens.

Nest comparisons - wood shavings only

The results in Table 4 show that no differences existed for egg production except in the first experiment. Egg production for hens in the full-trap nest was significantly lower than for the other treatments. As no training program was practiced there were many floor eggs. Percentage of floor eggs was greatest for the full trap hens so the lower production may be the result of lost floor

eggs. Hens appeared to prefer the OS, CS, and CDS nest types using low floor egg production as the criterion. Broken eggs were more numerous, however, for these nest types.

In Experiments 2 and 3, as in the first study, the semi-trap, nest in comparison to the community nest type, tended to have more broodiness, fewer broken nest eggs, higher egg production and more floor eggs.

Nest comparisons - shavings vs. turf

Statistically significant differences between nest treatments were detected for egg production, broodiness, percentage of broken eggs, and floor egg production (Table 5) in Experiment 4.

Egg production was significantly greater for the CTR group as compared to the STR treatment. Production by STR was low throughout the study and not explained by a high rate of broodiness. A bias may be present in the egg production data as this treatment had a very high incidence of floor eggs. Lost floor eggs and undetected broodiness could perhaps account for the difference in production rates.

The rollaway nests (STR and CTR) appeared to discourage broodiness somewhat and to reduce the amount of egg breakage. The turf-rollaway floor in the community nest decreased egg breakage below that of the semi-trap (SS) reversing a trend seen in other experiments where egg breakage was always greater in the community nest when shavings were used.

In Experiment 5 both the semi-trap and community nests were compared with shavings or with a turf-rollaway bottom (Table 5). No differences were detected for egg production over the 20 weeks of production. The lowered egg production by the STR nest seen in Experiment 4 was not observed in this study.

Nest type significantly affected egg breakage, floor egg production and broodiness. The turf-rollaway floor reduced egg breakage and broodiness. Floor egg production was greater with the rollaway floor in both nest types. The results agree partially with that of Experiment 4, i.e. higher floor egg production with the STR nest but not with CTR which had the lowest level of floor eggs in Experiment 4 but not in Experiment 5.

Production differences between the semi-trap and community type nests did not completely favor one nest type over another and the results were modified by nesting material. Egg production by the semi-trap nest tended to be greater but the incidence of floor eggs and broodiness was greater. The community nest tended to have a larger number of broken eggs. The turf material in combination with rollaway floor reduced broodiness and egg breakage but increased the incidence of floor eggs.

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Table 1. Relationship of dietary lysine content and reproductive performance (20 weeks) of large white turkey hens[1]

Experiment	Dietary level		Egg production	Egg weight	Body weight change	Feed intake	Lysine intake
	Protein	Lysine					
	%	%	%	g	kg	g/day	g/day
1	12	.32	51.5	85.9	- .96	218	.70
		.50	55.0	88.5	- .43	228	1.14
		.68	53.3	86.7	- .40	230	1.57
	14	.38	52.9	87.6	- .56	216	.82
		.53	52.3	89.2	- .20	233	1.24
		.68	51.5	88.6	- .32	225	1.53
	15.7[2]	.78	57.4	89.4	- .48	250	1.95
2	11	.29	51.9	85.0	-1.50	204	.59
		.34	53.2	86.4	-1.18	214	.73
		.41	53.1	85.9	- .99	215	.88
		.51	56.8	86.9	-1.04	212	1.08
	14	.36	53.6	87.3	-1.27	203	.73
		.41	54.3	87.3	-1.05	215	.88
		.51	58.1	87.5	- .78	218	1.11
	14[2]	.67	52.5	88.4	- .63	232	1.56

[1]4 and 6 pens per diet for Experiments 1 and 2, respectively

[2]Corn-soy control diet

Table 2. Effect of breeder protein level on 20-week reproductive performance[1]

Breeder dietary treatment	Egg production (%)	Egg weight (g)	Fertility (%)	Hatchability (%)	Feed consumption (g/day)	Body weight change (kg)
1. Control (15.7% protein)	54.4	87.9	90.0	85.8	247	- .72
2. Low protein (10.5% protein)	51.7	83.8	87.7	84.2	229	-1.30
3. As 2 + .15% lysine	56.0	83.6	88.3	86.0	242	- .81
4. As 3 + .07% methionine	57.9	84.4	89.3	85.1	240	- .98

[1]12 pens per diet

Table 3. Effect of breeder protein level on 20-week reproductive performance[1]

Breeder dietary treatment	Egg production (%)	Egg weight (g)	Fertility (%)	Hatchability (%)	Feed consumption (g/day)	Body weight change (kg)
1. Control	52.8	91.3	73.8	82.0	242	-.60
2. Phase protein	52.8	89.5	71.8	82.5	238	-.73

[1]24 pens per diet

Table 4. Effect of nest type with wood shavings for nest material on 20-week reproductive performance of large white turkey breeder hens[1,2]

Experiment	Nest type	Egg production	Broody hens	Broken eggs	Proportion of floor eggs
		----------%			----------
1	Full-trap (FS)	48.3	8.7	.8	47.3
	Semi-trap (SS)	56.6	8.4	1.5	28.8
	Open (OS)	58.8	6.2	3.2	13.4
	Community (CS)	53.2	5.0	2.6	16.5
	Community-door (CDS)	56.8	4.5	2.4	25.9
2	Semi-trap (SS)	53.4	3.3	1.9	18.9
	Community (CS)	52.3	2.1	3.0	16.7
3	Semi-trap (SS)	54.8	14.6	2.0	20.0
	Community (CS)	53.6	12.2	2.5	14.3

[1]Experiment 1 summarized over 24 weeks
[2]Number of pens per nest type was 10, 24, and 24, respectively, for Experiments 1, 2, and 3

Table 5. Effect of nest characteristics on 20-week reproductive performance of large white turkey breeder hens.[1]

Experiment	Nest type	Egg production	Broody hens	Broken eggs	Proportion of floor eggs
		----------%			----------
4	Semi-trap, shavings (SS)	55.3	9.9	2.8	28.9
	Semi-trap, turf, rollaway (STR)	51.8	4.6	1.0	59.2
	Semi-trap, turf (ST)	54.0	8.4	2.6	35.9
	Community, turf, rollaway (CTR)	58.9	5.9	1.6	20.6
5	Semi-trap, shavings (SS)	53.1	15.2	2.6	29.6
	Semi-trap, turf, rollaway (STR)	54.8	5.7	.9	51.4
	Community, shavings (CS)	50.7	10.3	3.5	14.8
	Community, turf, rollaway (CTR)	52.5	5.2	1.5	33.0

[1]12 pens per nest type.

SEASONAL EFFECT OF FAT SUPPLEMENT IN BREEDER DIETS - SUMMER VS. WINTER

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The annual uninterrupted marketing and processing of turkeys has dictated year-round production of poults. However, egg production by turkey hens has characteristically been less for summer flocks than for flocks producing eggs during the remainder of the year. To explain this seasonal variation many factors should be considered including environmental temperatures, food consumption, weight loss and diet.

Temperature, food consumption, and diet are closely related. As ambient temperature increases above the so-called comfort zone, turkeys exhibit two progressive and characteristic responses. Because of a reduced requirement for maintenance, there is an initial decrease in food consumption. As the ambient temperature continues to increase, hens simply refuse to eat. Contrary to broiler breeders, turkey hens lose weight during the egg production season (Cherms et al ., 1976). Robel (1984) suggested that by dietarily maintaining body weight, egg production could be increased. He reasoned that feed intake of turkeys is not sufficient to maintain both body weight and egg production. Horani and Sell (1977), Potter et al . (1978), and Grizzle et al. (1982) reported no significant increase in egg production using either 2, 4, or 6% added fat. A recent publication by Harms (1984) indicated an increase in egg production and decrease in feed consumption by addition of 8% added fat (Table 1).

Table 1. Performance of turkey hens fed diets with zero and 8% added fat.*

Added Fat (%)	Number Eggs/hen	Feed Consumption/ hen/day (g)	Energy Consumption/ hen/day (Kcal M.E.)	Body Weight (kg)	Egg Weight (g)
0	44.7	222	649	8.9	83.4
8	58.3	189	622	9.1	83.2

*Harms (1984)

In a study analyzing the effects of fat supplementation on feed restricted hens during the summer Hulet and Brody (1984) found increased egg production with 10% added fat diets (Table 2).

Table 2. Egg production and egg weight of turkey hens fed either 1% or 10% added fat during a 10 week production period.

	No. Eggs/hen		Egg Weight (g)	
	1% Fat	10% Fat	1% Fat	10% Fat
Ad libitum (AL)	28.0[a]*	35.6[b]	86.3	83.3
80% of AL	23.8[a]	26.6[a]	81.5	79.0
60% of AL	12.7[a]	17.2[b]	77.0	78.3

*Statistical differences at <.05 level within rows are indicated by different letters.

Egg production was consistently increased by the addition of 10% added fat to breeder diets while no consistent effect on egg weight was found. Feed consumption, however, decreased significantly in the full fed hens from 284g to 218g when fed the 10% added fat diet.

Based on the results obtained with the summer flock, an experiment to determine the effect of added fat in a winter flock. After a preconditioning light regime, hens were photostimulated (14L:10D) at 26, 28, 30 or 32 weeks of age and given either a 1% or 10% added fat breeder diet ad libitum. There were four replicate pens per treatment, with 10 hens/pen. All hens were trapnested.

Age at sexual maturity, eggs per hen, weekly mean egg weight every fourth week, feed consumption, and number of eggs/kg feed were recorded. Broody behavior was also monitored, with hens showing broody behavior placed in wire broody coops for a three day period. Birds were kept in production for a 22-week production period.

The results for the winter flock showed that fat supplementation had no effect on egg-production or egg-weight (Table 3).

Table 3. Winter time egg production and egg weight of fat supplemented hens in 22 weeks of production.

	1% added fat	10% added fat
Eggs/bird/week (1-10 weeks)	3.85	3.98
Eggs/bird/week (11-22 weeks)	3.17	3.21
Total eggs/bird/22 weeks	76.24	77.47
Mean egg weight (gms)	85.77	87.16

While no effect on egg number or weight was observed, there was a significant decrease in feed consumption by hens fed the higher energy diet (Figure 1). The dietary energy (Kcal/Kg ME) for the 1% added fat and 10% added fat breeder diets was 2903 and 3338 Kcal/Kg ME or 1317 and 1514.5 Kcal/lb. M.E., respectively. Feed consumption for the the birds fed the high fat breeder diet was decreased by 18% compared to the hens fed the 1% added fat diet during the winter time.

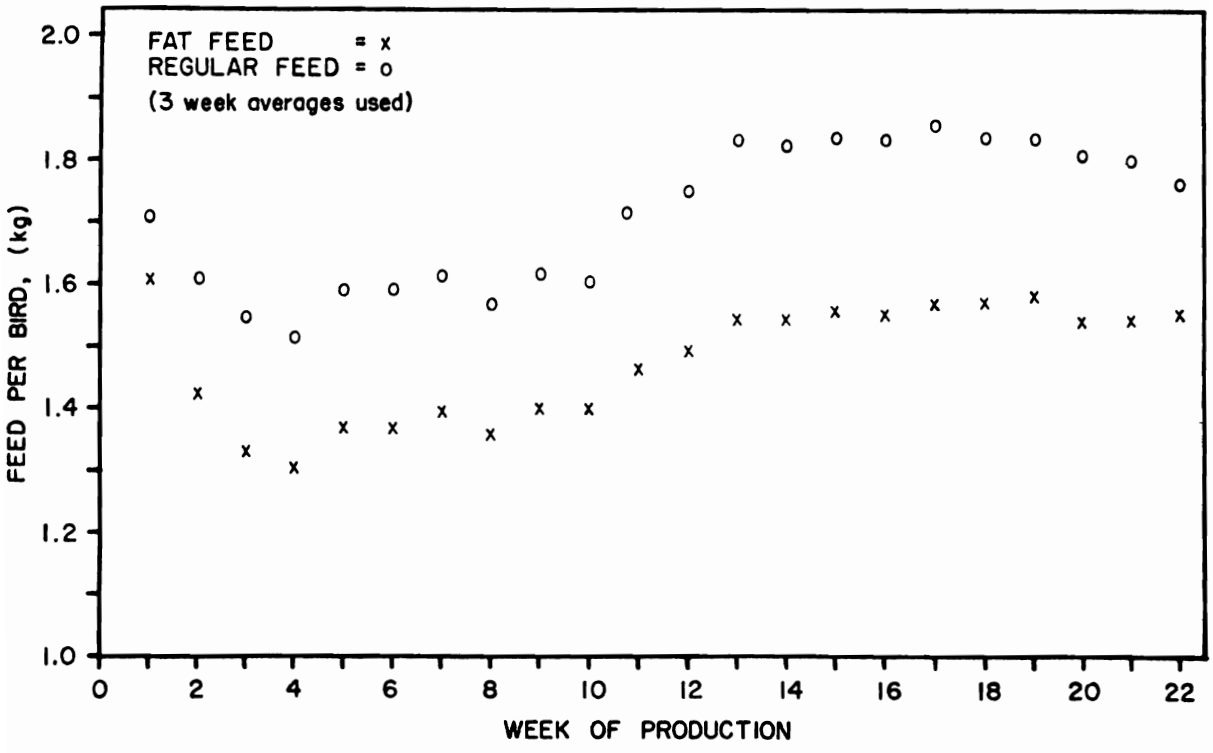

Figure 1. Feed per bird for turkey hens fed either 1% added fat (Regular Fed) or 10% added fat (Fat Fed) through an egg production period.

In conclusion, more work is needed to determine the action of dietary fat on egg production and to determine the optimum levels of fat for breeder diets. However, increased energy does appear to increase egg production during the summer and decrease feed consumption with no detrimental effect on egg production during the winter.

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FACTORS AFFECTING BROODINESS IN TURKEYS

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Broodiness is a major contributor to poor reproductive performance of breeder turkey hens. The decline in farm income associated with broodiness results from loss in hatching egg production and added labor needed to conduct a broody treatment program.

It is clear from many studies and from practical experience that numerous factors can influence broodiness in turkeys. The magnitude of broodiness is affected by the season of the year, housing conditions, age of hens, the genetics of the flock and the daily management of the flock. Also, it is clear that broodiness continues to be a problem in the turkey breeder business.

Hormones and Broodiness

Prolactin (PRL) is the hormone long suspected in broodiness. The PRL level in the blood of a broody hen is about 4-fold greater than the PRL level in laying birds. The level of prolactin changes dramatically during the reproductive cycle of breeder hens (Burke et al., 1981; Fig. 1). Before photostimulation PRL levels are low but within 7-16 days after the onset of photostimulation the levels begin to increase. These blood levels increase steadily until the birds come into lay. The levels then tend to stabilize for a variable period of time. Hens that continue laying maintain steady PRL levels week after week. However, hens that become broody show sharply rising PRL levels. Once broodiness is established the PRL levels remain very high. Circulating luteinizing hormone (LH) levels, a pro-gonadal hormone, follow the opposite pattern. The LH levels remain high before the onset of broodiness and a day or two before broodiness is established circulating LH levels decrease to their lowest levels. A dramatic decrease in feed consumption occurs in association with the onset of broodiness. Thus, a relationship between broodiness and PRL in the turkey is clearly established, but it is not clear whether the increase in PRL is the cause of broodiness or a result of it.

Brain Neurochemicals and Broodiness

While broodiness is closely regulated by PRL, it is also known that PRL is regulated by brain chemicals called neurotransmitters. We investigated the changes in brain neurotransmitters in relation to the reproductive cycle in breeder hens (El Halawani and Burke, 1976; Table 1). Following exposure to a stimulatory photocycle, the oviduct and ovarian weights increase. This is associated with an increased turnover rate in two neurochemicals namely, norepinephrine and epinephrine. As breeder hens become broody, the ovaries and oviducts undergo marked regression. Dopamine turnover

rate is increased in turkeys that are just becoming broody. On the other hand, serotonin turnover rate is greatly increased in long-term broody hens (hard broodies), but not in those just becoming broody. These results implicate serotonin in the cessation of gonadal function and egg laying when hens become broody.

Nesting and Broodiness

One of the main characteristics of broodiness is an increase in the amount of time a hen spends nesting. As mentioned above, PRL levels increase at the time of increased nesting frequency. Thereafter, the levels markedly increase and remain elevated as long as the breeder hen continues to be broody. Removal of broody hens from their nests and home pens and confinement in a slatted floor broody coop or in individual wire cages causes a drop in circulating PRL levels within 24 hours. The PRL levels remain low as long as the hens are away from their home pens.

In another study we found that breeder hens raised in cages exhibited a different PRL profile than the floor raised turkeys (El Halawani et al., 1984; Fig. 2). Cage reared breeder hens have consistently lower levels of circulating PRL than the floor reared turkeys. Moreover, none of the caged turkeys became broody and all hens continued to lay. These results point to the importance of nests in the management of broodiness.

Ambient Temperature and Broodiness

Breedermen have long recognized the poor reproductive performance of turkey breeder stock during the summer months. High ambient temperature adversely affects reproduction and is suspected to be responsible for the reduced reproductive efficiency during the summer season.

A study was designed to investigate the effects of ambient temperature on broodiness and circulating PRL and LH levels (El Halawani et al., 1984; Fig. 3). Breeder hens were maintained under ambient temperatures of 50°F (10°C) or 86°F (30°C) during their reproductive life cycle. Turkey hens reared at 86°F were the first to come into production following the onset of photostimulation. All the birds raised at the higher temperature became broody. These birds also showed an accelerated increase in PRL level during laying and broodiness. On the other hand, breeder hens reared at 50°F came into lay later than those raised at 86°F, but continued laying throughout the experimental period, not becoming broody. Circulating PRL levels of the 50°F group increased following the onset of photostimulation, but remained significantly below the levels of the 86°F group. These findings implicate high ambient temperature with broodiness in breeder turkeys.

Genetic Selection and Broodiness

Broodiness and intensity of lay, the two major determinants of egg

production in turkeys, are heritable (Nestor, 1972). Nestor (1982) has reported a decrease (19 days) in the total days lost from broodiness following 7 generations of selection. This was associated with an average increase of 11.7 eggs per hen. However, the selection for decreased broodiness and increased egg production was accompanied by 1.7 lbs and 1.0 lbs decreases in body weight for males and females, respectively, at 24 weeks of age.

Control of Broodiness

A better way needs to be developed to control broodiness, since selection for reduced broodiness also reduces body weight and management procedures to discourage hens from becoming broody are time consuming. A relationship between brain chemicals, the state of broodiness, and the association between high circulating PRL and broody behavior were discussed above. These findings taken together led to the conclusion that serotonin controls blood PRL and may be involved in the cessation of gonadal function and egg production when hens become broody. An experiment was conducted in which parachlorophenylalanine, a serotonin depletor was administered to broody hens (El Halawani et al., 1983). The results presented in Fig. 4 show that when parachlorophenylalanine was given to broody hens it prevented nesting and circulating PRL levels fell rapidly. The PRL levels remained low until the birds came back into lay when their circulating PRL increased slightly. There was an increase in circulating LH after the drug treatment.

The results demonstrate that parachlorophenylalanine suppresses raised blood PRL levels, decreases nesting frequency and increases LH levels in broody turkeys. This effect is associated with a return to a functional ovary characteristic of a laying turkey.

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Table 1. Brain neurotransmitters turnover rate of turkey hens during various phases of reproductive activity

	Dopamine	Norepinephrine	Serotonin
Laying hens	1.05 ± .51[a]	0.82 ± .14	1.18 ± .23[a]
Transitionally Broody	3.00 ± .73[b]	0.67 ± .08	1.39 ± .05[a]
Broody	1.34 ± .27[a]	0.71 ± .09	3.70 ± .08[b]

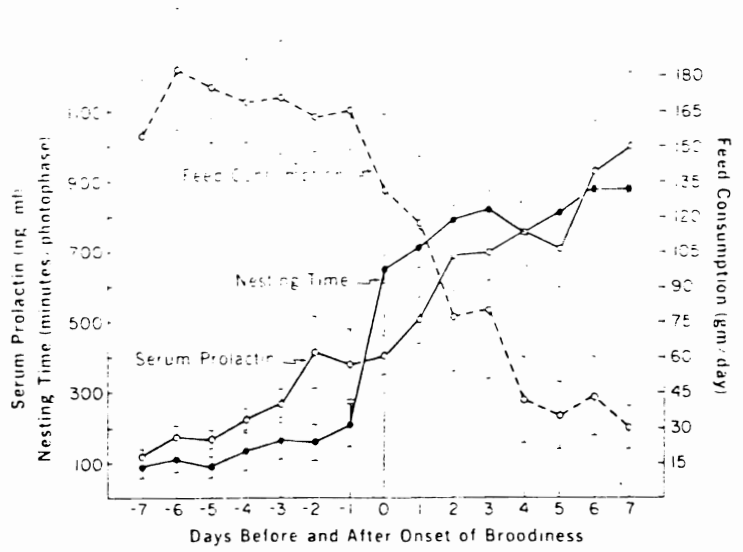

Fig. 1. Circulating prolactin levels, nesting time and feed consumption of breeder hen turkey before and after onset of broodiness

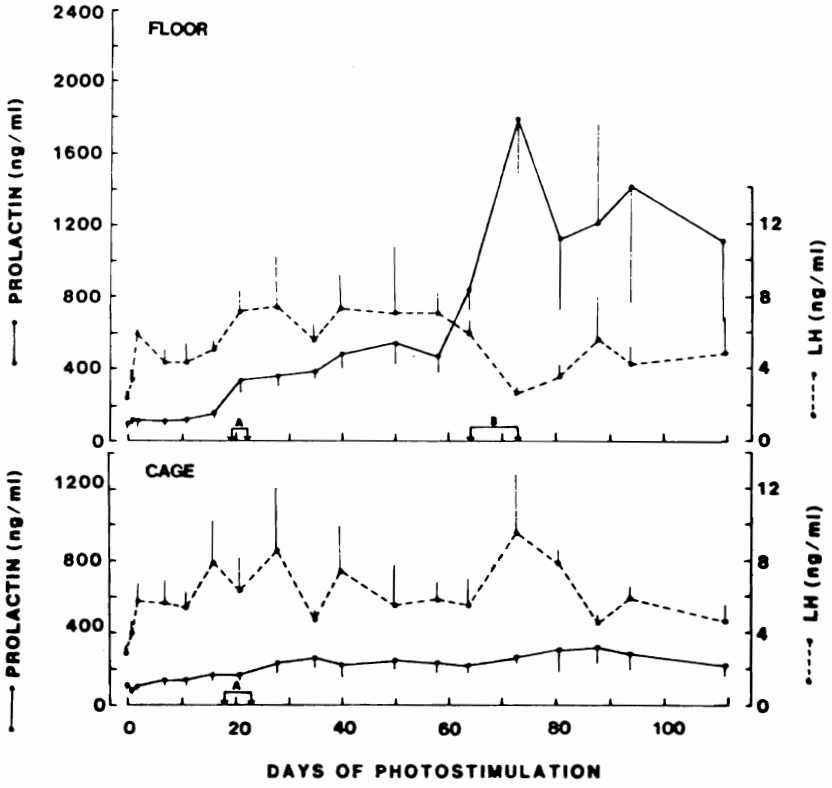

Fig. 2. Effect of cage rearing on prolactin and luteinizing hormone levels of breeder hen turkeys.

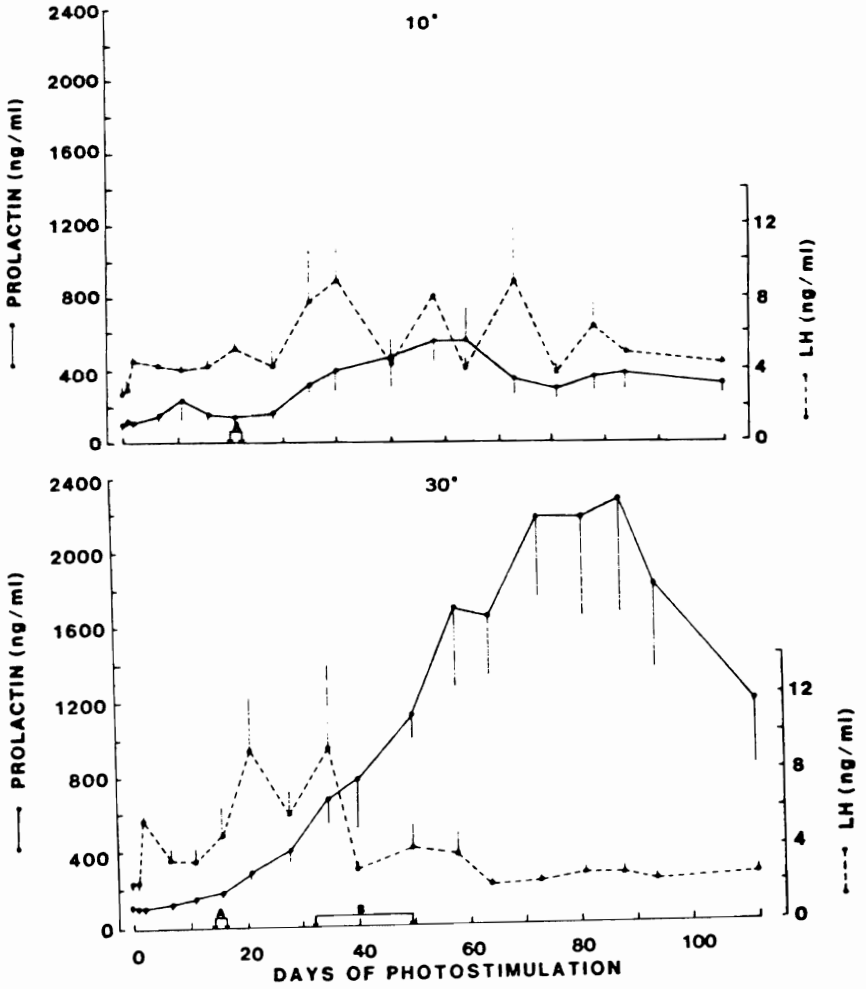

Fig. 3. Effects of ambient temperature on circulating prolactin and luteinizing hormone levels of breeder hen turkeys.

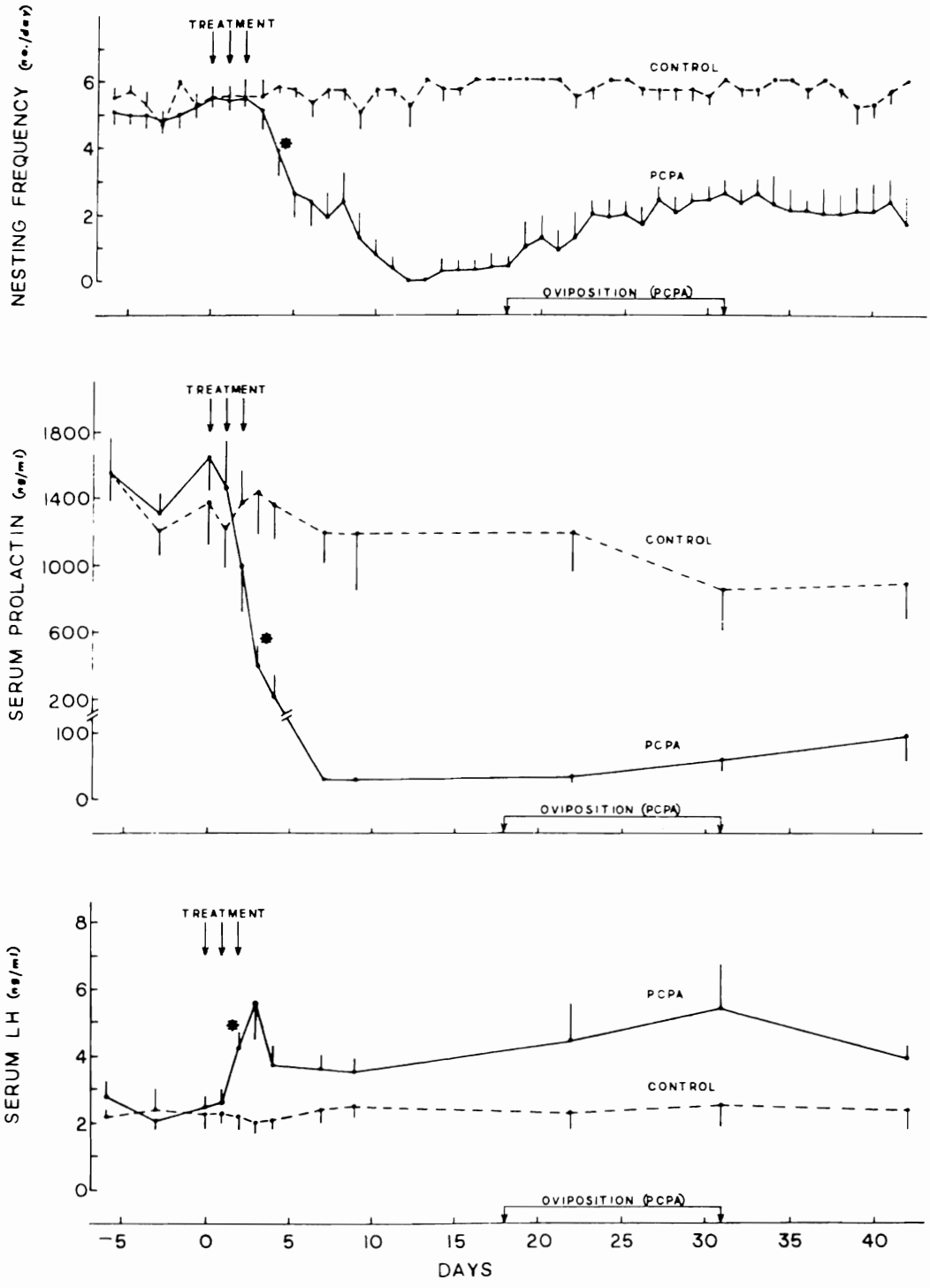

Fig. 4. Effects of parachlorophenylalanine on nesting frequency and circulating levels of prolactin and luteinizing hormone in broody turkeys.

VIRAL ENTERIC INFECTIONS OF TURKEY POULTS

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Enteritis in avian and mammalian species could be caused by a variety of infectious and noninfectious agents. Among the infectious agents, bacterial enteritis has been studied extensively. In the last decade, many viral agents were identified as causes of enteritis in mammalian species. Research on viral enteritis in poultry has been lagging a little, but in the last few years interest in this area has increased.

In this report, information is presented on the detection of viruses associated with enteritis in turkey poults. Also presented is information on the pathogenicity of selected viral isolates.

Intestinal contents from 36 flocks were submitted to our laboratory from Arkansas, California, Indiana, Iowa, Minnesota, Nebraska, North Carolina, Ohio, and Wisconsin. The samples originated from 10-21 day-old poults experiencing diarrhea, variations in size and increased morbidity and mortality.

Electron microscopy, immune electron microscopy and polyacrylamide gel electrophoresis were the techniques used for detection of these viruses. Bacterial isolations were attempted from all the samples submitted using standard bacteriological procedures.

Viruses were detected in 35 of 36 samples submitted. A rotavirus-like agent (RVLA) was the most common virus associated with diarrheal outbreaks in the samples examined, occurring in 65% of the flocks. Other viruses detected, in order of prevalence, were astroviruses, reoviruses, rotaviruses and enteroviruses. Very few samples had only one type of virus alone. Salmonella was isolated from only one of 36 samples submitted.

By electron microscopy, RVLA were morphologically indistinguishable from rotaviruses; however, immune electron microscopy was useful for differentiation of these two viruses. Turkey rotavirus reacted with antisera to porcine and bovine rotaviruses, whereas turkey RVLA did not. The RVLA was found to possess an RNA electrophoretic migration pattern different from that of conventional rotaviruses or reoviruses.

With the exception of coronaviruses (blue comb) and adenoviruses (hemorrhagic enteritis), little is known about the pathogenicity of

the other viruses detected. Studies are in progress in our laboratory in this area.

Several experiments indicated that a combination of an astrovirus and RVLA caused a profuse diarrhea in 2-week-old specific pathogen free poults accompanied by shedding of both viruses. Younger poults had a milder diarrhea when exposed to these agents. Rotavirus alone was associated with a very mild diarrhea.

It should be emphasized that viruses similar to those reported here have been associated with enteritis in mammalian species. Our knowledge is rather meager on the epizootiology, pathogenesis and control of enteric viruses of turkeys. The tools are currently available to investigate these problems and certainly in the near future more information on this problem will be generated.

CONTROL OF SALMONELLA BY IMMUNIZATION

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Salmonellosis in poultry is caused either by the host adapted serotypes: S. gallinarum and S. pullorum which may rarely infect man or by non-host adapted types which are very often pathogenic for man. Eradication programs for S. gallinarum and S. pullorum have been successful and on the whole they have resulted in the elimination of these serotypes from the poultry industry in U.S. Salmonellosis by non-host adapted serotypes is a major public health problem in the U.S. and many other countries. According to one estimate, approximately 2500,000 persons in the U.S. are affected each year by Salmonella and costs Americans up to $1.2 billion a year in medical expenses. About 30% of the outbreaks reported during the past seven years were poultry and egg related.

Economically salmonellosis presents a serious problem to the poultry industry through mortality and morbidity in birds. The poultry industry is highly integrated in the U.S. Few primary breeding companies produce almost all the multiplier breeding stock sold in this Country. The multiplier breeders in turn are responsible for the production of commercial meat and egg type birds. Any salmonella which gains access to the breeder hen at any time has the capability of being transmitted to the next generation. Once established in the succeeding generation it may then be passed to the next and then to the next generation and so on. Salmonellas are transmitted through the egg. Vertical transmission of salmonella via the egg from an infected breeding flock which invariably shows no clinical signs, to the off-spring is probably the greatest danger.

It is the usual practice under commercial conditions at the hatchery to inject day-old turkey poults with antibiotics to control the losses from salmonella infection. Unfortunately, these antibiotic injections do not eliminate the organisms but only reduce the mortality caused by the infection (1). Antibiotic prophylaxis or treatment can cause drug resistance and may produce the carrier state (2). The administration of adult microflora to day-old birds has proven to be protective against colonization by salmonella

(3, 4). However, such a product would have to be free of other disease producing agents and purified before it can be commercialized. Prophylactic vaccination is another possible method of prevention of salmonellosis.

There are two basic requirements for the large scale use of prophylactic vaccines. The vaccines must be both safe and effective. The effectiveness of a vaccine may vary with the method of its preparation. Adjuvants of many types from alum through oil emulsions to polynucleotides have been used in a variety of diseases and with adjuvant vaccines, the height of antibody response is considerably greater than with aqueous vaccines. In particular, oil emulsion vaccines impart a longer lasting immunity than obtained with aqueous conventional vaccines.

Research work was conducted by the staff of the Avian Disease Program at the College of Veterinary Medicine on the use of oil adjuvant vaccines for the control of Salmonellosis in turkeys. Laboratory and field studies indicate encouraging results on the use of these vaccines. In the following one such field study which was conducted is described with its results.

Vaccination for salmonella with a mineral oil adjuvant vaccine was examined in turkeys. The two main objectives were 1) to determine whether by vaccination it is possible to prevent salmonella infection of breeder flocks from their contaminated environment and 2) to examine whether it is possible to obtain salmonella free progeny from salmonella infected turkey breeder flocks.

A breeder/hatchery operation where salmonella infection of a particular serotype (S. san-diego) was self perpetuating in a cycle was selected. The breeder flocks in this facility were composed of grand parent and parent birds. The yearly operation involved approximately 26,500 breeder replacements and 20,700 breeders. The breeders were housed in 3 different locations. The breeder replacements were brooded for 4 months and then selected and moved to three breeding farms.

A comprehensive study of this breeder/hatchery operation showed evidence of cycling of salmonella infection. This was indicated by the isolation of the same serotype from live birds, their environment, hatchery debris and 10 day mortality. Breeder replacements produced from the operations own parent breeding stock served as a source of infection.

An autogenous mineral oil adjuvant vaccine was prepared from the salmonella serotype (S. san-diego) isolated from the breeder facility. The organism was grown in veal infusion broth at 37°C for 48 hours and inactivated with formalin. Using a continuous flow Sorval centrifuge ,the bacteria were harvested and the broth was discarded. Resuspension of bacteria was done in 0.85 % normal saline and concentration was adjusted to 0.25% transmission at a wavelength of 540. After the sterility of the suspension was checked, it was then mixed with mineral oil and Arlacel. This mineral oil adjuvant vaccine of S. san-diego was used to vaccinate the birds.

Breeder replacements at 18 weeks of age were vaccinated following the official salmonella testing program. One hundred percent of breeder replacements(#22230) were vaccinated. They were then housed in the breeder barns where there was a consistant history of the presence of S. san-deigo. The birds were given feed without animal by-products throughout the study. The vaccination was repeated once more at 10 weeks later. An extensive monitoring program on vaccinated flock and their eggs and progeny was instituted. Cloacal swabs from 10% of birds randomly selected were collected twice a month and examined for salmonella . During the laying cycle, hatchery debris, which included cull poults, infertiles, dead in shells, cloacal squeezings and fluff samples from each hatch, were monitored. The ten-day mortality in poults from the vaccinated flock was examined. Fifty random blood samples/flock vaccinated were examined for their serological response to the vaccine.

The hatchery debris and progeny from vaccinated flock remained negative for S. san-diego throughout the observation period. The breeder replacements were found negative for any salmonella on official test of the NPIP during the year. The height of antibody response was considerably greater in vaccinated breeders for S. san-diego. The enhanced antibody response to the mineral oil adjuvant vaccine seen in breeders in this experiment was assumed to result in increased degree of protection. The high antibody levels persisted at protective levels for considerably longer periods of time.

The use of autogenous mineral oil adjuvant bacterins of salmonella appears helpful in eliminating those serotypes which are otherwise cycling in an integrated operation.

Research is continued on the use of mineral oil adjuvant vaccine against infection by Salmonella hinshawii (Arizona).

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CURRENT KNOWLEDGE ON HEMORRHAGIC ENTERITIS (HE) VACCINATION

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Hemorrhagic enteritis (HE) is an acute viral infection of turkeys caused by Type II Adenovirus. The disease is characterized by massive hemorrhage in the intestinal lumen of the affected turkeys. The disease is seen in both range and confinement reared turkeys. Antibiotics, electrolytes, wormers, depopulation with clean-up and disinfection and many other approaches have been tried in the past to control the disease mostly without much success. On some occasions clean-up and disinfection following depopulation has diminished the severity of the disease in subsequent flocks.

Vaccination against HE has been practiced for the past few years to prevent this disease. Vaccination is achieved by the drinking water administration of a turkey-spleen propagated virus of pheasant origin in four week-old turkeys. The virus contained in splenic homogenates from these turkeys is alive and when administered is capable of multiplying in the vaccinated birds. This virus multiplication is important to achieve a significant antibody response in the birds receiving the vaccine.

Vaccination with splenic tissue homogenates, although considered to be effective, has many potential problems. The turkeys in which the vaccine is propagated must be free of transmissible diseases. If one fails to identify such diseases in the birds being used to prepare the vaccine, these diseases may be transmitted to the flocks(s) receiving the vaccine. This could result in a serious problem depending on the agent(s) being transmitted to the flock receiving the vaccine. In addition the vaccines are not often pretested and too little or too much virus may be given.

Because of these risks many attempts to grow the HE virus in a tissue culture system have been made. Two years ago the USDA Regional Poultry Research Laboratory (RPRL) at East Lansing, Michigan developed a procedure to propagate HE vaccine virus in cell culture. The cell line used is a white blood cell line of turkey origin. Laboratory evaluation of this cell culture HE vaccine has established its efficacy and safety. Repeated use of this vaccine at the RPRL has revealed it is safe and effective. Poults receiving 100 tissue culture infective doses of vaccine were protected against clinical signs of the disease following challenge. The efficacy of their cell culture HE vaccine was recently evaluated for the first time in a field trial in Minnesota. The field trial was a cooperative effort between a commercial turkey producer, research workers from RPRL and the University of Minnesota.

METHODS

The vaccine was field tested in 33,500 turkey poults in three separate buildings on the same farm. Birds in each building were divided equally and

placed on each end of the building with an entry-way between the ends. At four weeks of age, birds on one end of each of the three buildings were vaccinated with cell culture HE vaccine. The vaccine was administered in the drinking water. The other half of the birds in the three flocks were maintained as unvaccinated controls. The birds in both groups were monitored for antibody response, safety, livability and average body weights. The protection provided from the vaccination was determined by challenge studies. Fifty birds from vaccinated and unvaccinated groups were placed in isolation facilities at the University of Minnesota and were challenged orally with a virulent strain of HE virus.

RESULTS AND DISCUSSION

Serology indicated a good antibody response to the cell culture HE vaccine. The average livability in HE cell culture vaccinated birds was 2% better than unvaccinated birds.

The average body weight at market time in the vaccinated birds was 0.36 lbs. heavier than in the unvaccinated birds. No apparent adverse reactions were seen in birds given the vaccine. Vaccinated birds resisted experimental challenge.

These encouraging results obtained from this field trial have prompted some laboratories to produce cell culture vaccine and field test it on a wide scale.

CARDIO-PROTECTIVE EFFECTS OF EXOGENOUS CORTICOSTERONE IN TURKEY POULTS FED FURAZOLIDONE

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Round-heart disease (RHD) in turkeys is characterized by ventricular hypertrophy and dilatation. The syndrome arises spontaneously, but a similar condition can be induced in young turkey poults by inclusion of toxic doses of furazolidone (FZ) in the feed (Jankus et al., 1972; Czarnecki et al., 1974). The etiology of RHD is unknown.

Previous studies have shown that daily administration of cortisone acetate (CA) affords limited cardio-protection in both the spontaneous and drug-induced conditions. In an inbred group of poults from a flock of turkeys with a high incidence of spontaneous RHD, daily administration of 2 mg of CA significantly reduced mortality during the first 5 weeks post-hatch, delayed the time of peak mortality by 6 days, and decreased the incidence of cardiac dilatation (Staley et al., 1975). Subsequent studies in our laboratory (Czarnecki et al., 1980, 1983a) demonstrated that CA was effective in reducing the incidence and severity of cardiac dilatation in poults fed toxic levels of FZ. Adversely, CA significantly depressed body weight.

In birds, the major corticosteroid is corticosterone (COS). Its effect on the development of cardiomyopathy in poults has not been reported. In this study the major objectives were: 1) to determine the effect of exogenous COS on the development of spontaneous cardiomyopathy in commercial poults during the second week post-hatch and 2) to evaluate the effectiveness of exogenous COS on the development of FZ-induced cardiomyopathy in commercial poults 2-5 weeks of age.

METHODS

Sixty-three broad-breasted white toms of the Nicholas strain, obtained from a single hatch, were placed randomly in two pens. Beginning at 1 week of age, poults in the experimental pen were fed a ration containing 20 mg of COS/kg of ration. Poults in the control pen received the same ration, but without COS. At 2 weeks of age, the poults were screened utilizing the electrocardiographic (ECG) technic developed by Jankus et al. (1971) and modified by Czarnecki and Good (1980). Poults with abnormal ECG patterns in Leads I or II (aVF) were not used in the study. The poults (with normal ECG patterns) from each pen were placed randomly in two groups with 12 poults per group: control pen→I--maintained on control ration (control group) and II--maintained on a ration containing FZ at a dose of 700 ppm (FZ-fed group); experimental pen→III--maintained on a ration containing 20 mg of COS/kg of ration (COS group) and IV--maintained on a ration containing 20 mg of COS/kg of ration and FZ at a dose of 700 ppm (FZ-fed COS group).

Body weights and ECG recordings were obtained on a weekly basis beginning at 1 and 2 weeks of age, respectively. Necropsy findings scored at time of death included: a) dilatation of ventricles (very severe, +4; moderately severe, +3; moderate, +2; slight, +1; none, 0); b) ascites (as); and c) anasarca (an). Data were analyzed using the Student's t-test. Hypotheses of no difference among control and experimental poults per age in ECG interpretations were tested by t-test corrected for continuity (Snedecor, 1967). P values ≤ 0.05 were considered statistically significant.

RESULTS AND DISCUSSION

Table 1 shows the mean body weights for all poults at 1 and 2 weeks of age and the ECG data for all poults at 2 weeks of age. No significant differences in body weights were apparent between the two groups of poults. Likewise, the incidence of abnormal ECG patterns did not differ statistically. During the second week post-hatch, two control poults died but there were no mortalities in the COS group.

Table 2 shows the mean body weights and ECG data for poults 3-5 weeks of age. The mean body weights of poults in the COS group tended to be less than those in the control group at all ages studied, but these differences were not statistically significant. FZ treatment, either alone or combined with COS treatment, significantly depressed ($P \leq 0.001$) mean body weights at all ages when compared to control poults. This effect of FZ on body weight has been documented previously (Czarnecki et al., 1974; Czarnecki and Jankus, 1975; Czarnecki and Sujarit, 1979). Significant differences in the ECG data were observed in the FZ-fed poults at 4 and 5 weeks of age when compared with control poults of similar ages. Incidence of cardiomyopathy in the FZ-fed COS poults was considerably less than that of the FZ-fed poults. At 4 weeks of age, 56% of the FZ-fed poults exhibited abnormal ECG patterns compared to 25% of the FZ-fed COS poults. By 5 weeks of age, 78% of the FZ-fed poults were affected compared to 50% of the FZ-fed COS poults. During the fourth week post-hatch there were 3 mortalities in the FZ-fed group including one poult euthanized because of a splay condition. One poult from the FZ-fed COS group died during the fifth week of the study. In addition, 3 poults from this group died from the stress of being handled on the last day of the study before ECG data could be obtained.

Table 3 summarizes the incidence of ventricular dilatation, ascites and anasarca in all FZ-treated poults. In individual poults, the extent of ventricular dilatation was greater in the right ventricle than in the left ventricle. This is in agreement with a previous study in which it was shown that in FZ-induced cardiomyopathy dilatation of the right ventricular lumen precedes that of the left ventricular lumen (Czarnecki et al., 1983b). Degree of ventricular dilatation was somewhat less in the FZ-fed COS poults than in the FZ-fed poults, but these differences were not statistically significant. Incidence of anasarca and ascites was comparable in both FZ-treated groups.

Results of this study indicate that COS is effective in delaying the onset and reducing the incidence of FZ-induced cardiomyopathy. Under the conditions of this study COS is less effective in decreasing the extent of ventricular dilatation and in delaying mortality. COS had little or no effect on mortality or the development of abnormal ECG patterns in commercial turkey poults 1-2 weeks of age. These effects of COS are similar to those reported for CA (Staley et al., 1975; Czarnecki et al., 1980, 1983a).

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Table 1. Mean body weights (g) for poults at 1 and 2 weeks of age and ECG data for poults at 2 weeks of age.

	Group[A]	Body weight	ECG[B]
1 wk.			
	I	119.4 ± 2.8[C](32)[D]	-
	II	112.7 ± 2.2 (31)	-
2 wks.			
	I	253.1 ± 7.2 (30)	N(27),N_H(1),NT(1),RT(1)
	II	239.5 ± 3.8 (31)	N(27),N_H(1),NT(1),RT(2)

[A]I--control; II--corticosterone.

[B]ECG: N--normal, N_H--normal, high voltage on Lead I; NT--normal transitional; RT--round-heart transitional.

[C]Mean ± standard error of the mean.

[D]Number of poults.

Table 2. Mean body weights (g) and ECG data for poults at 3, 4 and 5 weeks of age.

	Group[A]	Body weight	ECG[B]
3 wks.			
	I	475.0 ± 10.8[C](12)[D]	N(12)
	II	451.3 ± 8.5 (12)	N(11),NT(1)
	III	372.8 ± 15.6 (12)**	N(11),N_H(1)
	IV	349.4 ± 7.9 (12)**	N(11),R(1)
4 wks.			
	I	810.4 ± 37.6 (12)	N(12)
	II	763.3 ± 13.4 (12)	N(12)
	III	502.1 ± 19.0 (9)**	N(4),N_H(1), RT(1),R(3)*
	IV	458.8 ± 19.1 (12)**	N(9),RT(1),R(2)
5 wks.			
	I	1345.3 ± 54.5 (12)	N(12)
	II	1243.5 ± 19.7 (12)	N(12)
	III	654.8 ± 28.3 (9)**	N(2),RT(2),R(5)**
	IV	625.4 ± 22.8 (8)**	N(4),RT(2),R(2)

[A]I--control; II--corticosterone; III--FZ-fed; IV--FZ-fed corticosterone.

[B]ECG: N--normal; N_H--normal, high voltage on Lead I; NT--normal transitional; RT--round-heart transitional; R--round-heart.

[C]Mean ± standard error of the mean.

[D]Number of poults.

*Significantly different from control group: *$P \leq 0.05$, **$P \leq 0.001$.

Table 3. Incidence of ventricular dilatation, ascites and anasarca in FZ-treated poults.

	Ventricular Dilatation[A]											
	0		+1		+2		+3		+4			
Group[B]	RV	LV	RV	LV	RV	LV	RV	LV	RV	LV	as[C]	an[D]
III	1*[E]	1*[E]	0	4	5	2	2	3	4	2	6	2
IV	3	3	1	2	2	6	2	1	4	0	7	2

[A]Ventricular dilatation: 0--none; +1--slight; +2--moderate; +3--moderately severe; +4--very severe.

[B]III--FZ-fed; IV--FZ-fed corticosterone.

[C]Ascites.

[D]Anasarca.

[E]Number of poults; *poult euthanized (splay).

REGULATION OF AVIAN GASTRIC FUNCTION

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In recent years our studies of digestive function in turkeys have evolved from attempts to describe digestive processes into investigations of the regulation of these processes. Some of this work has been previously summarized (Duke 1981,1982).

The function of the gastric apparatus has long been of special interest to us (e.g. Duke et al., 1972; 1975; Dziuk and Duke, 1972) and it continues to be. Gastric secretion and contractile activity (i.e., motility) may be under three general phases of regulation: cephalic, gastric, and intestinal. The cephalic phase occurs when an animal "senses" (visually, via olfaction, etc.) that it is about to eat or is eating. The gastric phase is initiated by food arriving in the stomach and the intestinal phase is activated by the arrival of food in the duodenum. This regulation may occur via either nerves or hormones.

In the past we've examined cephalic (Duke et al., 1976; Duke and Evanson, 1976), gastric (Duke et al., 1977), and intestinal (Duke et al., 1972b; Duke and Evanson, 1972) phases in the regulation of gastric motility. Our more recent studies have been designed to examine cephalic and gastric phases of gastric secretion and the effect of avian pancreatic polypeptide (aPP) on gastric secretion and motility. Since aPP is released from the pancreas into the bloodstream after an animal eats, it is believed to be involved in the gastric and/or intestinal phase of regulation. Mammalian research has found that pancreatic polypeptide (PP) may depress pancreatic and biliary secretion but it has no effect on gastric secretion or motility. There have been only two previous studies on the effect of aPP on avian gastric function and these concluded that aPP stimulates gastric secretion (Hazlewood et al., 1973) and depresses motility (Duke et al., 1979). In these avian studies aPP was administered intravascularly (i.v.) as a single bolus and since administration via a constant i.v. infusion is currently believed to be more physiological, these studies may not have provided evidence of the actual function of aPP. We decided, therfore, that this work should be repeated using infused aPP.

We prepared SCWL hens with a cannula in the jugular vein for infusing aPP, a cannula in the proventriculus to allow collection of secretions, and a tiny strain gauge transducer implanted on the gizzard to permit detection of contractile activity (Duke et al., 1984). After recovery from the surgery, the birds were fasted for 24 hours in order to reduce the level of aPP in the blood to a basal level, and then either physiological saline (a control infusate) or an aPP solution was infused. aPP was infused at a level of either 7.5 ng/ml of plasma, a low post-prandial level, or 15 ng/ml of plasma, a moderately high post-prandial level.

The contractile frequency of the gizzard was statistically significantly depressed by both the 7.5 and 15 ng/ml infusions. Contractile amplitude was also depresessed, but not significantly (Table 1). Secretory volume was significantly depressed, but only at the 15 ng/ml level of aPP. Secretrory volume during the 7.5 ng/ml infusion and pH and the concentration of pepsin at both aPP infusion rates were also depressed, but not significantly (Table 1).

These findings differ from those of the earlier avian studies in which bolus injections were used. However, the present findings using an infusion of aPP probably more truely represent the actual role of aPP in regulation of gastric function. The present findings also differ from what is known about PP function in mammals. Because the upper portion of the avian gut is quite different structurally from that of mammals and also functionally with a crop for storage and a gizzard for mastication, it isn't too surprising to find these differences in regulation.

A similar study is currently under way to determine the effect of infused aPP on pancreatic and biliary secretion in hens.

Previous researchers have demonstrated that the sight of food initiated gastric secretion in ducks, geese and a barn owl, but this evidence of cephalic regulation could not be demonstrated in chickens (see Duke and Bedbury, 1984). The presence of food in the crop, however, did reportedly stimulate gastric secretion in chickens. Also, stimulation of the lateral hypothalamus, a brain area known to be involved in cephalic regulation of gastric function, with substances known to cause gastric secretion in mammals, caused secretion in chickens. The vagus nerves are involved in this secretory response in mammals, and vagal stimulation causes gastric secretion in chickens (see Duke and Bedbury, 1984). So, the mechanism for cephalic regulation of gastric secretion exists in chickens.

To further study the cephalic phase we implanted cannulas in the proventriculus of several SCWL hens. The hens were fasted for 24 hours, then gastric secretions were collected with no food in view, food in view but covered by plexiglass, and with food available.

Neither volume, pH nor pepsin content of gastric secretions was significantly changed when fasted birds were allowed to see food but not eat (Table 2). Thus, we could not demonstrate the existence of a cephalic phase of gastric secretion in chickens. When the hens were allowed to eat we did observe significant changes in gastric secretion (Table 2); this demonstrates a gastric phase of gastric secretion.

In the early 1900's researchers suggested that the avian stomach is divided into three parts, the crop, glandular stomach and muscular stomach, with the crop being analogous to the cardia of the mammalian stomach. The close coordination of the contractile activities of the crop and stomach (Duke, 1984) also suggests that the crop might correctly be considered to be a portion of the avian stomach. Therefore, stimulation of gastric secretion in chickens by food in the crop, may actually be a demonstration of the gastric phase of gastric

secretion rather than the cephalic phase. In any case, the presence of the crop orad to the stomach may decrease the functional necessity for a cephalic phase of gastric secretion.

Another factor that may also lower the need for a cephalic phase, particularly in chickens, is that chickens have been maintained for many generations with abundant food constantly in sight (if they chose to look at it). Perhaps through natural selection, the sight of food is no longer a pertinent stimulus in chickens. It is probably not an efficient use of bodily resources to have secretions released upon seeing food when food is in constant view. The existence of a cephalic phase of gastric secretion has not been examined in domestic turkeys but a cephalic phase of gastric motility has been demonstrated (Duke et al., 1976), and turkeys have not normally been maintained in cages with food in constant view. It would be interesting to investigate the cephalic phase in other galliforms, not maintained as chickens have been and in other species with well developed crops.

There eventually will be significant advantages in knowing how digestive processes are regulated, and the relationship of hormones to this regulation seems especially important. Hormones that slow passage rate of food through the gut (aPP) or stimulate secretion of digestive enzymes could improve efficiency of utilization of diets. Hormones that stimulate appetite could be useful during anorexia. Recent research has discovered other hormones that influence intestinal absorption or secretion in mammals, these could be extremely useful during diarrhea. Feeding specific nutrients or combinations of nutrients that initiate release of hormones would avoid having to administer them. More information is needed, however, before we will be able to use hormones in this way. Thus, research such as described herein must continue.

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Table 1. Mean gastric contractile frequency and amplitude and volume, pH and pepsin content of gastric secretions during infusion (i.v.) of either physiological saline or aPP at two concentrations in chickens.

Gastric Functions	Infusate (n=12) saline	Infusate (n=12) 7.5 ng/ml aPP	Infusate (n=16) saline	Infusate (n=16) 15 ng/ml aPP
Contractions				
Freq. (no./min)	1.14 ± 0.55	0.35 ± 0.15*	1.3 ± 0.49	0.26 ± 0.16**
Amp. (g)	50.4 ± 11.9	31.3 ± 9.5	36.5 ± 5.61	21.9 ± 5.9
Secretion				
Vol. (ml/min)	0.08 ± 0.09	0.05 ± 0.05	0.01 ± 0.08	0.04 ± 0.04*
pH	2.13 ± 0.98	1.57 ± 0.14	1.61 ± 0.39	1.52 ± 0.29
Pepsin (P.U.)	2264 ± 470	2207 ± 849	2575 ± 446	2449 ± 319

*Mean during aPP infusion was statististically significantly different than the mean during saline infusion ($P<0.01$).

**Mean during aPP infusion was statistically significantly different than the mean during saline infusion ($P<0.001$).

Table 2: Mean (± standard deviation) volume (ml/min), pH and pepsin content (P.U./ml) of gastric secretions of chickens during three 20 min. periods designated "no food" (food not available following 24 hr. of fasting), "seeing food" (food pan in view but a plexiglass cover prevented feeding), and "eating food" (cover removed)

	No Food	Seeing Food	Eating Food
Volume	0.199^a (±0.02)	0.219^a (±0.02)	0.286^b (±0.02)
pH	1.94^a (±0.94)	1.87^a (±0.10)	2.78^b (±0.10)
Pepsin	$3{,}308^a$ (±115)	$3{,}219^a$ (±126)	$2{,}625^b$ (±164)

Means in the same line with different superscripts are significantly different ($P<0.05$).

STUDIES OF DIGESTION IN YOUNG TURKEYS WITH YUCCA SAPONIN ADDED TO THE FEED

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It was previously reported (Johnston et al., 1981) that yucca saponin fed to broilers at 63 ppm resulted in significantly improved weight gains at 28 and 51 days of age. When yucca saponin was fed to broilers at 63 ppm in combination with monensin at 99 ppm or 121 ppm, yucca saponin did not significantly increase body weights at 51 days of age (Johnston et al., 1982); however, saponin improved feed efficiency of broilers when fed with 121 ppm of monensin.

Saponin fed at low levels (31 or 155 ppm) increased egg production and reduced ammonia levels in the hen house (Rowland et al., 1976). Poults exposed to 200 ppm atmospheric ammonia had reduced feed intake and growth rate during exposure and subsequently had reduced egg production and increased mortality (Deaton et al., 1984). In poultry high concentrations of ammonia from the litter causes harm to the respiratory tract and increases susceptibility to respiratory tract infections. Turkeys exposed to 10 and 40 ppm ammonia had more virulent inhaled pathogenic Escherichia coli in their lungs, air sacs and livers than those poults not exposed to ammonia (Nagaraja et al., 1984). From these results, it was hypothesized that one mechanism of action of yucca saponin in improving performance in poultry might be the reduction of ammonia concentration in the atmosphere of the poultry house.

The objectives of the present study were to determine effects of yucca saponin on several digestive functions in turkeys and to obtain information regarding the mechanism for the improved performance previously reported by others for broilers.

MATERIALS AND METHODS

Turkey Maintenance. Three trials were performed. Wrolstad Medium White male and female poults were used in the first and second trials. Nicholas Broad White female poults were used in the third trial. All poults were obtained from commercial sources at 6 weeks of age and were housed in cages in environmentally controlled rooms. In the first trial 29 turkeys were compared by establishing saponin vs. control (not fed saponin), cecectomized vs. intact, and male vs. female groups. In the second trial cecectomies were not done and 42 turkeys were separated into saponin vs. control and male vs. female groups.

In the third trial 68 female turkeys were divided into 6 groups as shown:

Group	No. of Poults	No. of cages	Ration (Saponin/Control)
1	18	6	Saponin
2	6	6	Saponin
3	18	6	Control
4	6	6	Control
5[a]	10	10	Saponin
6[a]	10	10	Control

[a] [Groups 5 and 6 were maintained in a room in which ammonia was released from a tank at a rate to maintain an atmospheric concentration between 30 and 35 ppm.]

Groups 1 and 3 were placed 3 per cage in order to study the effects of crowding. Groups 5 and 6 were exposed to ammonia for 5 weeks to study the effects of atmospheric ammonia.

Yucca saponin was mixed in a ration (Table I) at 63 ppm. The concentration of ammonia was measured once each 2 days with an infrared ammonia meter.[2] Natural production of ammonia from excreta in the litter was minimized by daily removal of excreta which accumulated on the paper beneath cages.

Measurements. In the first two trials food intake, water intake and dry matter excretion were measured over a 72-hour period each week for 8 weeks. Body weights were determined weekly. In the third trial body weights, food consumption and food conversion were measured weekly for 6 weeks. Data were statistically compared using weighted repeated measures in an analysis of variance.[3]

RESULTS

Trials 1 and 2. Data on food and water intake, weight gain, food conversion and digestion coefficients are summarized in Tables 2 and 3. There were no significant differences in weight gains, food conversion and digestion coefficients when comparing male with female, saponin fed with control fed and cecectomized with intact groups of poults. Control fed female poults had a significantly greater average food intake than those fed the same ration containing 63 ppm yucca saponin, Table 2. However, there were no significant differences in food intake in the male groups. Saponin fed poults consumed significantly greater amounts of water than the control groups, Table 3, Trial 1. In Trial 2 water consumption was significantly lower in the saponin fed males when compared to the saponin fed females and the control fed male and female poults, Table 3. Cecectomized poults in the saponin fed and control fed groups consumed more water than the intact saponin fed and intact

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[2]Miriam 101, Wilks Scientific Corp., South Norwalk, CT.
[3]BMDP Statistical Software, Program BMDP2V, University of California Press, Berkely, CA 1981.

control fed groups, Table 3, Trial 1.

Trial 3. Saponin fed poults did not have significantly different average weight gains or food intakes when stressed by crowding (3 poults per cage) or by adding ammonia to the atmosphere (30 -35 ppm) and when compared to the nonstressed control groups, Table 4, parts A and B. During the last 5 weeks of the trial, there were no significant differences in mean values for food intake and weight gains between noncrowded poults exposed to 30-35 ppm atmospheric ammonia and noncrowded poults housed in a separate room without added ammonia, Table 4, underlined mean values.

DISCUSSION

Although there were statistically significant differences in isolated groups in food and water intake, the important measures of production (weight gain and food conversion) were not improved by saponin feeding in poults at 6 to 14 weeks of age. Perhaps steroidal anabolic activities of the yucca saponin act only in sexually mature individuals. Cecectomy did not alter the saponin effect. It was anticipated, if saponin increases weight gains by improving microbial digestion, that cecectomy would eliminate part or all of the beneficial effect of saponin in the poult. The lack of response may indicate that saponins only alter weight gains in those species which derive major energy sources from microbial digestion.

Poults which were crowded and exposed to atmospheric ammonia did not perform better when fed 63 ppm saponin than the control fed poults. Perhaps the stresses used in these experiments were not severe enough to bring about significant harm.

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Table 1. Ingredients and calculated nutrient composition of ration

Ingredient	%
Corn, ground yellow	53.14
Soybean meal solvent	40.56
Fish solubles SBM[1]	1.80
Fermentation residue prod[2]	.18
DL - Methionine (99)	.11
Dicalcium phosphate	2.19
Calcium carbonate	1.31
Sodium chloride	.40
Vitamin mix (MTS-74)[3]	.20

Calculated nutrient composition[4]	
Dry matter (%)	89.53
Metabolizable energy (kcal/kg)	2778.12
Protein (%)	23.64
Fat (%)	2.51
Fiber (%)	4.21
Calcium (%)	1.09
Phosphorus (Total %)	.84
Potassium (%)	1.02
Magnesium (%)	.18
Sulfur (%)	.22
Sodium (%)	.23
Chlorine (%)	.33
Iron (%)	.03
Copper (mg/kg)	14.76
Manganese (mg/kg)	81.69
Zinc (mg/kg)	83.32
Selenium (mg/kg)	.27
Vitamin A (IU/kg)	9990.14
Vitamin D3 (ICU/kg)	3306.90
Vitamin E (IU/kg)	23.99
Vitamin K (mg/kg)	2.20
Riboflavin (mg/kg)	7.31
Pantothenic acid (mg/kg)	17.33
Niacin Av. (mg/kg)	68.14
Choline (mg/kg)	1952.19
Vitamin B12 (mcg/kg)	9.01
Folic acid (mg/kg)	1.20
Vitamin B6 (mg/kg)	7.09

[1] Fish solubles product is fish solubles dried on soybean meal at 100% equivalence (52% protein).

[2] Fermentation residue product, Fermacto - 500 (Borden, Inc., Northbrook, IL).

[3] Department of Animal Science, University of Minnesota, St. Paul, MN.

[4] Calculated from NRC feed ingredient tables, Nat. Res. Council (1977) Nutrient requirements of poultry, 7th ed., National Academy of Science, Washington, D.C.

Table 2. Summary of 8-week poult performance for both trials 1 and 2 [a,f]

	Saponin		Control	
Parameter	Male (15)	Female (21)	Male (21)	Female (14)
Food intake[b]	420	400[x]	416	418[y]
Weight gain[c]	182	168	177	172
Food conversion[d]	2.30	2.39	2.36	2.42
Metabolizability coefficient[e]	.69	.66	.70	.68

[a] Means within rows with different superscripts are significantly different ($P \leq .01$).

[b,c] gm/kg body weight - week.

[d] $\frac{\text{food intake}}{\text{weight gain}}$.

[e] $1 - \frac{\text{fecal output}}{\text{food intake}}$.

[f] Numbers in parentheses are the number of poults in the group.

Table 3. Water intake in ml/kg body weight/day by turkey poults during an 8-week period in trials 1 and 2[a]

Trial 1

Saponin diet (15)[b]				Control diet (14)			
1168[w]				1000[x]			
Cecectomized (7)		Intact (8)		Cecectomized (6)		Intact (8)	
1304[w]		1049[x]		1186[y]		860[z]	
Male (4)	Female (3)	Male (6)	Female (2)	Male (3)	Female(3)	Male (6)	Female (2)
1352	1240	1060	1018	1168	1205	851	932

Trial 2

Saponin (21)		Control (21)	
Male (5)	Female (16)	Male (12)	Female (9)
845[w]	932[x]	946[x]	923[x]

[a] Means within rows with different superscripts are significantly different ($P \leq .01$).

[b] Numbers in parentheses are the number of poults in the groups.

Table 4. Summary of 5 to 6- week poult performance in trial 3[a,d]

Part A, Effect of poult density

	Saponin		Control	
	3 poults/cage (18)[c]	1 poult/cage (6)	3 poults/cage (18)	1 poult/cage (6)
Weight gain[b]	243	234 213	248	256 227
Food intake[b]	500	511 472	524	525 486

Part B, Effect of atmospheric ammonia

	Saponin (10)	Control (10)
Weight gain	210	205
Food intake	468	483

[a] Mean values within rows were not significantly different.

[b] gm/kg body weight - week.

[c] Numbers in parentheses are the number of poults in the group.

[d] Values which are underlined are means for a 5-week period.

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