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The Nebraska Poultry Report

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The 1994 Nebraska Poultry Report

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Introduction

The Nebraska Poultry Report is produced every two years by the Animal Science Department's poultry faculty with contributions from others in the University of Nebraska who work with avian species. The purpose is to make our activities known to the poultry industries in Nebraska. The majority of articles are based on on-going research but are written in a relaxed style for ease of reading. If at any time an article or piece of information is of special interest to anyone in the industry, we hope you will contact us to discuss it.

Nipple Waterers for Chick Brooder Units: Design, Efficiency, Cost Analysis

Tami M. Brown
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Heated brooder units, commonly called starting batteries, are used in research at universities across the country. Although no mechanical maintenance and little cost are associated with trough waterers, the troughs have many disadvantages. Because they are stationary and do not remain at ideal back-level height throughout the growing period, contamination with feed and feces necessitates frequent disinfection. Troughs can be both labor intensive and inconvenient. Reliable administration of medication or other water — soluble treatments is difficult, and water consumption cannot be accurately monitored. The covering screens are only of limited adjustment range, and do not accommodate changes in chick height.

The objective of this project was to design an add-on nipple unit to replace the trough system on a chick starting battery, and to compare construction and operating cost of the new system with the original system. Water quality and chick performance were also prime concerns, as was ease of water line manipulation (e.g., treatment administration) and water consumption data collection.

Methods

Two Petersime 2SD-24 batteries were used, with each pen divided to give 4 pens/level; 24 pens/battery were equipped with conventional stainless steel troughs or the nipple system described below. The basic nipple unit is shown in Figure 1; Ziggity 1025 nipples were installed at the outer end of each level, one nipple per pen, on an adjustable mount to allow for growth of chicks over the three-week growing period. A pressure regulator (Ziggity LP100) was installed at each level, in parallel, to ensure uniform flow rate to all pens. The nipples were monitored to ensure uniform flow rates; the flow rate through each nipple was tested in replicates of three at three pressures. A second regulator was designed to allow uniformity through gravity, while permitting easy access to water lines for research purposes (Figure 2).

Results

Nipple Construction and Efficiency:

The construction cost of the nipple system per battery was calculated to be ~$400 (Table 1), approximately twice the cost of the troughs. Cleaning time per battery for a three-week experiment was found to be ~490 min (troughs) versus 85 min (nipples) (Table 2), a saving of 6.75 hr per battery per trial. The time required to train chicks to use the nipples was substantially less than the time required to maintain trough waterers. Based on an average labor cost of ~$8.00/hr, savings in labor would offset the initial cost of replacing troughs with nipples with seven three-week trials. If the nipple system were purchased outright with the battery, the savings offset would be realized within four three-week trials.

Nipple flow rates are shown in Figure 3. From the regression analysis, the variability among nipples is consistent between measures. This, in

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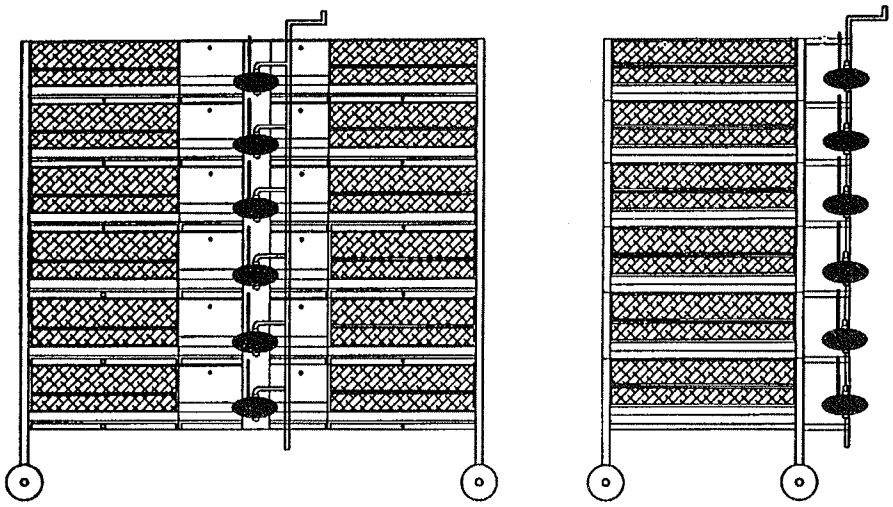

Figure 1. Basic nipple unit.

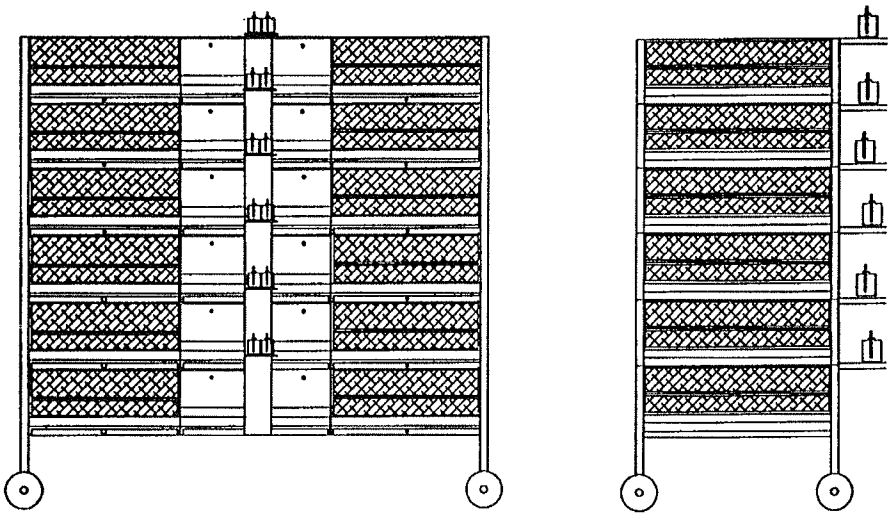

Figure 2. Second regulator designed to allow uniformity through gravity, while permitting easy access to water lines for research purposes.

addition to the R^2 value, indicates the variation is associated with nipple construction and with slight differences in the water pressure rather than with inherent problems in the regulators. This slight variability in pressure did not affect the variation in chick performance.

Chick Trial:

A chick performance trial was conducted to test experimental accuracy in the nipple system and to monitor time spent maintaining the system. Eighty-four day-old Vantress x Arbor Acre chicks were randomly assigned to pens in batteries equipped with nipples (Figure 1) or troughs. Each battery contained seven replicated pens with six birds per pen. Both groups were fed a corn-soy diet (22.6% CP, 3041 kcal/kg ME), and were exposed to a 24-hr photoperiod. Weight gain, feed conversion, and mortality were recorded weekly from zero to three weeks. During week three of the trial, water samples were collected into autoclaved test tubes from the nipple by depressing it with a stainless steel spatula that had been sterilized in an alcohol flame. Water from troughs was collected 24 hr after last disinfection directly into autoclaved test tubes. Samples from three different pens per battery were collected, pooled together and plated on blood agar to compare bacterial levels.

There wereno significant differences overall in weight gain, feed conversion or mortality; however, on a weekly basis feed conversion differed between the two types of batteries. Dur-

Table 1. Construction Cost Analysis for Nipple Watering System

Item	Cost	No. Units	Total Cost
Ziggity 1025 nipples	$ 1.00	24	$ 24.00
Start-grow units	2.20	12	26.40
PVC pipe	0.09	18	1.62
Aluminum brackets	5.00	12	60.00
PVC T-connectors	0.59	3	1.77
PVC 90 degree elbow	0.35	3	1.05
Rubber tubing	0.32	72	3.04
6 ft garden hose	4.00	1	4.00
PVC cement	5.00	1	5.00
Pin valve	3.50	1	3.50
5/16 inch threaded rod	0.75	6	4.50
5/16 inch nuts	0.05	24	1.20
1/2 inch conduit brackets	0.50	6	3.00
Ziggity LP100	38.00	6	228.00
1000 ml roller bottle	2.00	12	24.00
Support bracket	3.00	6	18.00
TOTAL COST			$ 429.08

Table 2. Operating Cost Comparison

Item	Trough System	Nipple System
Disinfecting watering units	300	——
Filling waterers	150	——
Scraping manure trays	40	40
Acclimating birds	——	45
Total (minutes)	490	85

ing week one, the chicks using trough waterers had better feed conversion than did those using nipples (1.51 vs. 1.70; P = 0.09), perhaps because the troughs were somewhat more readily accessible. By week three, the reverse was true, with chicks using nipples having the better feed conversion (1.40 vs 1.63; P = 0.05). It should be noted that the feed conversion of chicks using nipples improved throughout the three-week trial, while those using troughs showed a significant reversal between week two and three (P = 0.003).

Although troughs were cleaned daily, water from the troughs had greater bacterial contamination (contiguous coverage by colonies vs. 12 colonies per plate from nipple samples). It is possible that this reduced contamination contributed to the higher feed conversions with nipples seen in week three.

In conclusion, the nipple system appears to be a viable and attractive alternative to troughs on chick starting batteries. This system provides cleaner (less bacteria) and continual fresh water to the birds. Reduced costs of labor and disinfectants offset the extra initial cost. Because the lines can be easily manipulated for water consumption, data collection, and water treatments, this system would be excellent for research purposes, in contrast to the troughs, which do not lend themselves to these activities.

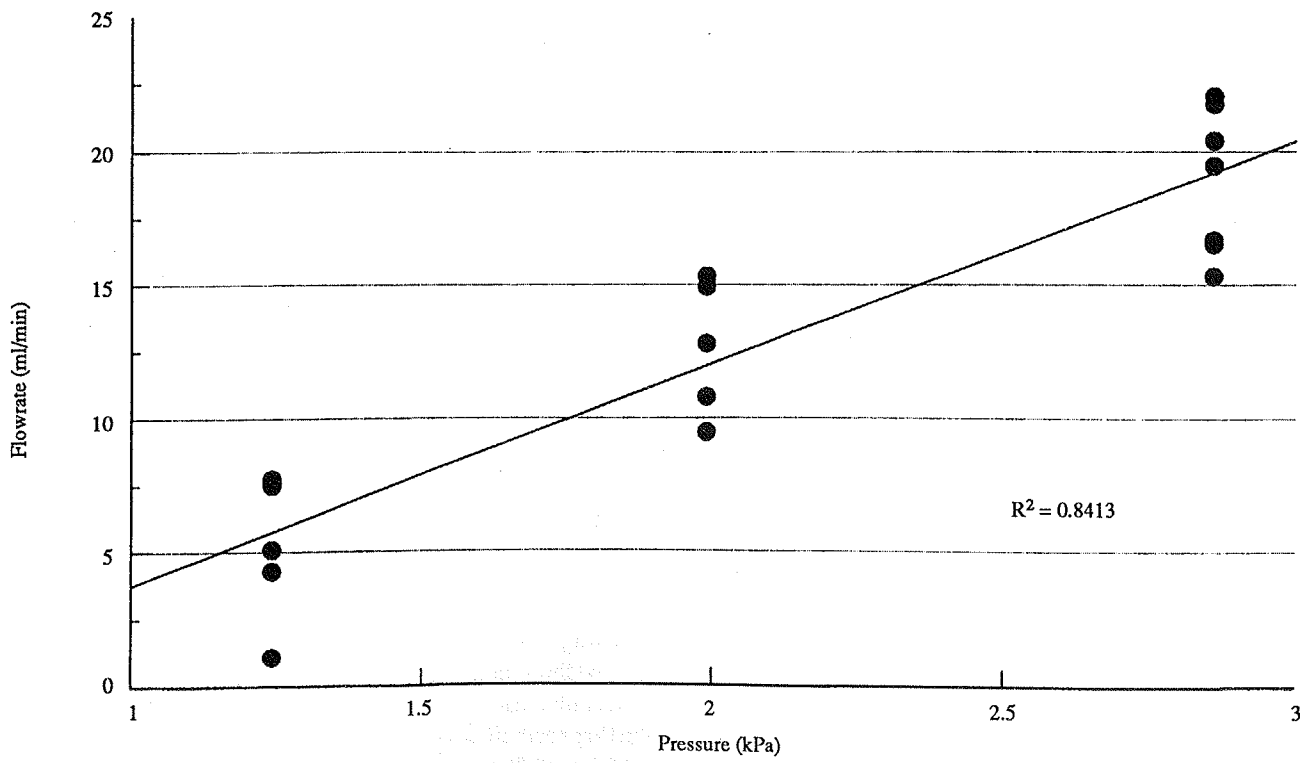

Figure 3. Flowrate through the battery.

Dietary Flaxseed for Poultry: Production Effects, Omega-3 Fatty Acid Incorporation Into Eggs and Sensory Analysis

Sheila E. Scheideler
Susan L. Cuppett
Glenn W. Froning

"Designer" eggs have drawn quite a bit of attention lately, especially since the report of Kinsella et.al. (1990) indicating a link between dietary omega-3 fatty acid consumption and cardiovascular disease. The egg has a unique potential as a dietary source of omega-3 fatty acids, due to the hen's ability to deposit dietary excesses into the egg yolk. Before further marketing of designer eggs takes place, more research is necessary to identify optimum feeding level of flax, without having an effect on sensory properties and potential anti-oxidative properties of Vitamin E in hen diets containing flax seed.

Dietary flax is a rich source of linolenic acid, which has been shown to dramatically increase the omega-3 fatty acid content of eggs (Caston and Leeson, 1990 and Jiang et.al. 1992). In fact, dietary flax is one of the most concentrated sources of linolenic acid available in natural feedstuffs for poultry. Flax seed contains as much as 35% oil, of which 55% is linolenic acid. Caston and Leeson (1990) reported a highly significant increase, from .38 to 8.9% linolenic acid in the egg, when diets included 20% dietary flax seed. Jiang et.al. (1992) reported similar increases when feeding 15% flax seed, but also reported a high incidence (36% of respondents) commenting on a fishy flavor in eggs from flax-fed chickens. This fishy flavor was speculated to come from oxidation of the flax seed oil prior to consumption by the laying hens.

Table 1. Flax Trial 1. Dietary Compositions

	Diet				
Ingredient	Fish Control	5% Oil	10% Flax	15% Flax	Flax
Corn	53.47	54.16	49.73	46.30	42.87
Oats	5.07	5.00	6.90	8.68	10.45
Flax	f	f	5.00	10.00	15.00
Soybean meal	20.46	20.36	18.10	15.70	13.30
Meat & bone meal	7.00	7.00	7.00	7.00	7.00
Animal tallow	3.22	1.22	3.17	2.25	1.33
Corn oil	.66	.64	f	f	f
Oyster shell	5.00	4.97	5.00	5.00	5.00
Dical. phos.	1.53	1.53	1.52	1.51	1.50
Limestone	2.59	2.62	2.57	2.56	2.54
Salt	.35	.35	.35	.35	.35
DL-Methionine	.20	.20	.20	.20	.20
Vitamin E Premix	.25	.25	.25	.25	.25
Vitamin/mineral Premix	.10	.10	.10	.10	.10
Choline chloride	.05	.05	.05	.05	.05
Grit	.05	.05	.05	.05	.05
Cost/ton (6/2/93)	$137.00	$149.00	$135.00	$134.00	$133.00
Nutrient Analysis:					
Protein, %	18.00	18.00	18.00	18.00	18.00
Metabolizable energy, Kcal/lb	1300	1300	1300	1300	1300
C18:2	1.65	1.65	1.96	2.63	3.32
C18:3	.09	.12	2.42	4.75	7.08
Ether extract, %	6.93	6.42	7.92	8.72	9.52
Fiber, %	2.72	2.72	3.06	3.39	3.73
Calcium, %	4.00	4.00	4.00	4.00	4.00
Total phosphate, %	.94	.94	.94	.95	.96
Available phosphate, %	.40	.40	.40	.40	.40
Methionine, %	.51	.51	.50	.50	.50
TSAA, %	.76	.76	.76	.76	.76

Experimental Design and Procedures

Eight diets (control; fish oil control; and 5, 10 or 15% whole or ground flaxseed) were fed to four replicate pens

Table 2.

A. Flax Trial 1. Production Results

Diet		Feed Consumption (g/day)	Weight Gain/Loss (g)	Egg Production (%)	Egg Weight (g)
1	Control	101.4	86.3	83.1	63.5
2	Fish Oil	103.4	77.5	93.0	63.1
3	5% W. Flax	95.9	23.5	88.2	61.3
4	5 % G. Flax	97.1	39.0	91.8	62.3
5	10% W. Flax	101.2	(-)51.0	86.3	62.9
6	10% G. Flax	103.8	66.0	91.6	63.5
7	15% W. Flax	101.3	(-)60	89.3	62.3
8	15% G. Flax	97.2	(-)46.7	86.0	61.3
(p value)		.05	.05	.01	.01
Time (p<value)		.05	.05	NS	.01

B. Flax Trial 1. % Egg Yolk and Fatty Acid Composition

Diet		% Yolk	C18:2	C18:3	C22:6
1	Control	29.20	12.67	.26	.52
2	Fish Oil	27.60	13.33	.38	2.87
3	5% W. Flax	28.00	12.42	2.01	1.83
4	5% G. Flax	26.10	12.51	2.61	1.44
5	10% W. Flax	29.50	12.49	4.23	1.70
6	10% G. Flax	28.20	13.02	4.13	1.77
7	15% W. Flax	28.60	14.60	7.07	1.78
8	15% G. Flax	28.20	14.81	6.59	1.81
(p<value)		.01	.05	.05	.05

C. Flax Trial 1. Taste Panel Data

Diet		Appearance	Texture	Flavor	Off-Flavor	Overall
1	Control	9.03	8.98	8.49	4.18	8.63
2	Fish Oil	8.74	8.13	8.05	4.72	8.06
3	5% W. Flax	8.69	8.18	7.84	5.95	7.69
4	5% G. Flax	9.09	9.12	8.72	4.55	8.41
5	10% W. Flax	8.50	8.79	7.97	4.79	7.72
6	10% G. Flax	7.41[1]	8.40	6.99[1]	5.61	6.92
7	15% W. Flax	8.51	8.61	7.87	4.88	7.79
8	15% G. Flax	7.16[1]	7.50	7.18[1]	5.11	7.42

[1]These samples were statistically different from the other samples in their appearance and flavor.

with three Dekalb Delta SCWL hens per pen. The diets were fed for eight weeks. Egg production and feed consumption were measured daily. Both hen and egg weights were measured weekly. At seven weeks, eggs were collected from each pen for breakout (determination of percent yolk, albumin, and shell), interior quality (Haugh units), fatty acid composition, cholesterol, TBA oxidative products, and taste panel sensory analysis. Diets are shown in Table 1. Flax seed for these diets was of the golden variety and was provided by the Flax Institute, Fargo, ND. Diets were formulated to be isonitrogenous and isocaloric and to meet the NRC (1984) requirements for Leghorn hens in their second phase of egg production.

Egg cholesterol and fatty acid composition were determined by gas chromatography methods as reported by Froning et.al. 1990. TBA values were determined on fresh and stored eggs at two, four, and six weeks of storage by the procedures of Tarladgis, et al., 1960 and Pikul et al., 1983. The taste panel flavor analysis was conducted in the Food Science taste panel room. Eggs were scrambled and evaluated by 12 panelists on a nine-point descriptive scale (Amerine, et al., 1965).

Results and Discussion

Dietary flax effects on production characteristics are shown in Table 2A. Diet significantly affected all the production parameters: feed consumption, egg production, weight gain or loss, and egg weight. Feed consumption was reduced in three of the flax treatments (5% whole and ground flax and 15% ground flax) compared to the control. These same three treatment groups lost hen weight between the start and end of the study, during a period when they should have had a steady increase in weight. Egg weight responded accordingly. The diets with less feed intake and body weight loss had significantly lower egg weights. Flax treatment did not have a detrimental effect on egg production. In fact, compared to the control diet, all flax treatments had significantly higher rates of egg production. However, compared to the fish oil control, their egg production rate was not equal. The negative effect of some of the flax diets on feed consumption and egg weight may have been due to subtle differences in dietary energy and protein. Although they were formulated to be equal, chemical proximated analysis will have to be done to assure there were no formulation errors. Otherwise, it does not make a lot of sense that the 5% flax diets show a negative effect, while the 10% and 15% flax diets do not show the same.

Dietary effects on percent yolk and on egg yolk fatty acid composition are shown in Table 2B. Diet significantly affected egg yolk, specifically decreasing egg yolk size in the fish oil treatment eggs and several of the flax treatments. Yolk size is related to dietary intake of fatty acids and some key amino acids. The effect of flax on egg size was not consistent. Dietary incorporation of

(Continued on next page)

the key fatty acids into the eggs was as efficient as expected. The level of C18:3 increased proportionally as dietary flax increased. There was not a marked difference in deposition of fatty acids from ground versus whole flax. The fish oil control diet was most efficient in depositing the long chain C22:6 fatty acid.

Egg sensory analysis for trial 1 is shown in Table 2C. Only two of the measured parameters showed statistical differences. The 10% and 15% ground flax treatments decreased consumer preference for scrambled eggs appearance and flavor compared to the other dietary treatments. TBA products of the eggs after two, four, and six weeks of storage were actually very low, and did not show consistent dietary effects. Egg haugh units and cholesterol were not significantly affected by dietary treatments.

Conclusions

Up to 15% dietary flax can be safely added to layer diets without any production detrimental effects, if properly balanced for energy and protein. Whole flax seed is preferable to ground flax seed in consumer acceptance of the egg produced. The brown variety tested showed more favorable results for egg production compared to the golden variety but was not as acceptable by the egg consumer. Levels of 10 to 15% dietary flax yield eggs with 4 to 7% yolk C18:3 fatty acids, respectively, making these egg rich sources of "omega-3 fatty acids."

Use of Killed Oil-Emulsion Infectious Laryngotracheitis Vaccines for Poultry

E. A. Wallner-Pendleton

Infectious Laryngotracheitis (LTV) is a severe upper respiratory illness of chickens caused by a herpes virus. Clinical signs in affected flocks include considerable mortality, due to both necrotic and hemorrhagic tracheitis.

While commercial vaccines have been available for a long time, outbreaks still occur, even in vaccinated flocks. Of major concern to the poultry producer is the fact that recovered birds, or even vaccinated poultry, may be persistent viral carriers and present a disease threat.

The purpose of this study was to determine whether the use of live vaccines, combined with revaccination with experimental killed vaccines, would result in improved protection against challenge with a virulent LTV virus. In addition, previously immunized then challenged birds were tested for virus shedding.

Methods

Experiment 1

One-hundred-twenty-five commercial DeKalb strain pullets raised free from exposure to LTV were brought to the University of Nebraska Veterinary and Biomedical Sciences Animal Isolation Facility. The birds were placed into five groups of 25 each in separate isolation rooms. All were fed a standard pullet rearing diet and kept on a natural light program.

Each room was assigned one of five treatment groups:

Group 1 Controls, no vaccination

Group 2 Received one injection of killed embryo origin vaccine at seven weeks.

Group 3 Received two injections of killed vaccine, four weeks apart.

Group 4 Received one live tissue culture vaccine (eye drop) at seven weeks.

Group 5 Received one live vaccination followed by killed vaccination four weeks later.

All birds were blood tested at housing and four weeks after the final vaccination. They were then challenged with a virulent LTV virus donated by Dr. Becky Hyde at the National Veterinary Services Laboratory in Ames, Iowa. The virus was administered directly into the trachea.

Table 1. Experiment 1

Group no.	Treatment used	Prevaccination titer (GMT*)	Post-Vaccination titer (GMT*)	Morbidity	Mortality	Virus isolation
1	No LTV vaccination	1	2	100%	56%	N/A
2	Received 1 injection of killed embryo origin vaccine at 7 weeks subcutaneously	1	661	80%	64%	N/A
3	Received 2 injections of killed embryo origin vaccine, 4 weeks apart	13	4,621	50%	8%	N/A
4	Received 1 live tissue culture vaccine eye drop at 7 weeks	1	3	18%	0%	10/10
5	Received 1 live tissue culture vaccine, followed by killed embryo origin vaccine 4 weeks later	49	10,175	0%	0%	1/10

*GMT denotes geometric mean titer.

Results of the serology and challenge study are found in Table 1.

Ten birds from group 4 and 10 birds from group 5 were euthanized, and their tracheas aseptically harvested and sent to Biomune Laboratory for virus isolation (Table 1).

These results suggested the killed LTV vaccine used in the experiment was inadequate for protection of flocks against the disease. Interestingly enough, the single dose of tissue culture vaccine still allowed for almost 20% respiratory signs in the flock, though no mortality was seen. The most favorably protected group appeared to be those which had received the combination live tissue culture and killed embryo origin vaccines. Not only were they 100% protected, but virus isolation rate was greatly decreased, when compared to the live vaccine only group.

Experiment 2

A second experiment was then completed using some new vaccination groups. Two types of live commercial vaccines were used, one from live tissue culture, the other from live embryos. Killed vaccines derived from both embryos and tissue culture were also used.

Two-hundred-ten Leghorn pullets, raised in isolation from LTV were divided into one of seven treatment groups. They were housed in an identical manner to those in Experiment 1. The treatments were as follows:

Group 1 No LTV vaccinations.

Group 2 Live tissue culture vaccine at seven weeks via eye drop.

Group 3 Live tissue culture LTV at seven weeks followed by killed LTV vaccine (tissue culture) at 13 weeks subcutaneously.

Group 4 Live tissue culture LTV vaccine at seven weeks, followed by killed LTV vaccine (embryo origin) at 13 weeks.

Group 5 Live chick embryo origin vaccine at seven weeks, followed by killed (tissue culture) vaccine at 13 weeks.

Group 6 Live chick embryo origin vaccine at seven weeks, followed by killed (embryo vaccine at 13 weeks.

Group 7 Live tissue culture vaccine at seven weeks, followed by live (tissue culture) vaccine at 13 weeks.

At 17 weeks, all birds were blood sampled and sera were sent to a private laboratory to test for LTV Elisa titers to monitor vaccine response (Table 2). Following serology, all birds were challenged with LTV virus obtained from NVSL. The virus was administered both intratracheally and by eye drop. The birds were monitored daily for signs of illness and mortality (Table 2).

One month after challenge, 10 birds from each treatment group were euthanized and their tracheas aseptically removed and individually placed in virus isolation media. They were then shipped on dry ice to Biomune for virus isolation attempts (Table 2).

Summary and Discussion

Several interesting observations were made from the above two experiments. Obviously, killed vaccines alone are inadequate for protection against LTV. It also appears that the attenuated tissue culture vaccine used did not provide complete protection against respiratory disease when administered only once. It did provide some, though incomplete, protection against mortality in experiment 2. It should be noted that an increased challenge dose was used in experiment 2, as well as intratracheal and eye-drop challenge. Our administration of the live tissue culture vaccine was done via eye-drop under ideal laboratory conditions. In field situations, producers have attempted to administer this product several different ways, including in the drinking water, through spray, and the eye-drop method. It appears possible that some vaccine breaks may be the result of using these alternative

(Continued on next page)

Table 2. Experiment 2

Group no.	Treatment Used	Prevaccination titer (GMT*)	Post-Vaccination titer (GMT*)	Morbidity	Mortality	Virus isolation 4 wks PC
1	No LTV vaccination	1	1	79%	37%	1/10
2	Live tissue culture (TC) vaccine at 7 weeks via eye drop	2	73	20%	17%	0/10
3	Live tissue culture LTV at 7 weeks followed by killed LTV vaccine (TC) at 13 weeks subcutaneously	1	333	20%	17%	1/11
4	Live tissue culture LTV vaccine at 7 weeks, followed by killed LTV vaccine (embryo origin) at 13 weeks	496	255	23%	0%	1/10
5	Live chick embryo origin vaccine at 7 weeks, followed by killed (TC) vaccine at 13 weeks	4	14,475	19%	0%	10/10
6	Live chick embryo origin vaccine at 7 weeks, followed by killed (embryo origin) vaccine at 13 weeks	615	20,363	0%	0%	10/10
7	Live tissue culture vaccine at 7 weeks followed by live tissue culture vaccine at 13 weeks	1	202	0%	0%	7/10

*GMT denotes geometric mean titer.

vaccination methods, which do not deliver a consistent vaccine dose. Based on these experiments, we would recommend using the attenuated tissue culture product via the eyedrop method, through two vaccinations for reliable protection.

The best protection against respiratory disease and mortality occurred when two immunization protocols were used: (1) two live tissue culture vaccinations by eye-drop, and (2) live embryo origin vaccination followed by killed embryo origin vaccine subcutaneously, 4-6 weeks later. The live tissue culture/killed embryo origin vaccine combination also protected well, with minimal respiratory signs observed and no mortality, even under our severe challenge.

In analyzing the serological responses to the vaccination, it is obvious that the killed vaccines induced a higher antibody response. High Elisa titers did not always correlate with protection (Tables 1 and 2). Of some concern were the high prevaccination titers observed in experiment 2 in groups 4 and 6. The chickens had not been vaccinated, and were housed until six weeks of age in a separate building, a good distance from the commercial pullet farms. One cannot, however, rule out that perhaps some LTV exposure had occurred. Serology for LTV has always been problematic. While AGID test is relatively insensitive, SN's are accurate but both expensive and time consuming. The ELISA may be useful for measuring trends in antibody response, but others have reported that non-specific reactions are common with LTV. We may never know whether or not those groups were truly exposed to LTV before vaccination.

The post-challenge virus isolation results showed some inconsistencies between experiments 1 and 2. In experiment 1, only groups 4 and 5 were assayed for virus two weeks post-challenge. In experiment 2, all groups were analyzed for virus shedding. In both experiments, the live tissue/killed embryo vaccination group showed only one positive isolate out of ten samples submitted. Unfortunately and unexpectedly, the best-protected groups in experiment 2 also had the highest virus isolation rate. The survivors from the groups showing highest morbidity and mortality also had the lowest virus isolation rate. Perhaps the ability to survive severe challenge with LTV allowed the host animal to reduce virus carrier status in the respiratory tract. From these experiments there is no way of knowing if any of the vaccination protocols affected the number of animals harboring virus in the trigeminal nerve ganglia.

Based on these results, the best vaccination protocol for the producer would be either two live tissue culture LTV vaccinations, or a combination live tissue culture or live embryo origin vaccine followed 4 to 6 weeks later by a killed embryo origin product.

The Use of Ultraviolet Radiation to Reduce *Salmonella* and Psychrotrophic Bacterial Contamination on Poultry Carcasses

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S. S. Sumner
G. W. Froning
L. E. Stetson

Salmonellae are among the most important pathogenic organisms causing food-borne disease. Many approaches have been adopted in attempt to reduce the incidence of contamination. The following measures are aimed at controlling *Salmonella* dissemination at various stages of poultry production and during processing by application of decontamination treatments and rinses.

Fresh, refrigerated poultry has a short shelf life. Fresh broilers in retail outlets may have an initial contamination level of 10^4 to 10^5 microorganisms per centimeter^2 and can be stored unfrozen by the consumer for only a few days at 3 to 5 C and still maintain their freshness. Spoilage organisms, which may produce off-odors, can cause consumer rejection of the product. Many of these spoilage organisms grow at normal refrigeration temperatures, hence their collective name "psychrotrophic" or "cold loving" bacteria. The initial microbial count greatly influences broiler shelf life.

The principal method for control of bacteria on meat is refrigeration. Other methods that have been used include washing with chlorine, air scrubbing, ozone, organic acids, gamma irradiation, and trisodium phosphate. Of these methods, the most effective technique is gamma irradiation. Unfortunately, gamma irradiation has not had broad acceptance in the United States because of public mistrust.

The use of ultraviolet (UV) radiation to reduce microbial populations in red meats and fish has also been documented. Despite the known properties of UV radiation, its potential to reduce bacterial contamination on poultry carcasses has not been well studied. The following project was conducted at the University of Nebraska to evaluate specifically the effect of UV radiation on *Salmonella*, as well as psychrotrophic bacteria, on broiler carcasses. The UV-treated carcasses were also evaluated for changes in color, rancidity, and shelf life.

Ultraviolet Radiation Equipment

A UV radiation apparatus was constructed by the University of Nebraska-Lincoln, Biological Systems Engineering Department (Figure 1). This apparatus consisted of an octagon-shaped .96-meter-long tubular light-tight structure. Within the structure, eight reflector-type major series UV germicidal units were placed on the inside walls, equidistant from each other. These units housed single G36T6 Model 4136 germicidal 253.7 nm UV lamps. The inside of the UV cabinet, including the lamp housing units, was lined with a highly reflective material to increase UV intensity and minimize any shadowing effect when irradiating irregular samples. A metal chain and standard meat hook were suspended from the top and center of the chamber. The UV intensity at the center of the chamber was measured using a spectronic Type DM-254N UV radiometer at the beginning and end of each experiment. Lights were turned on approximately one hour prior to each study. A clear, sliding-glass door, which was impenetrable to

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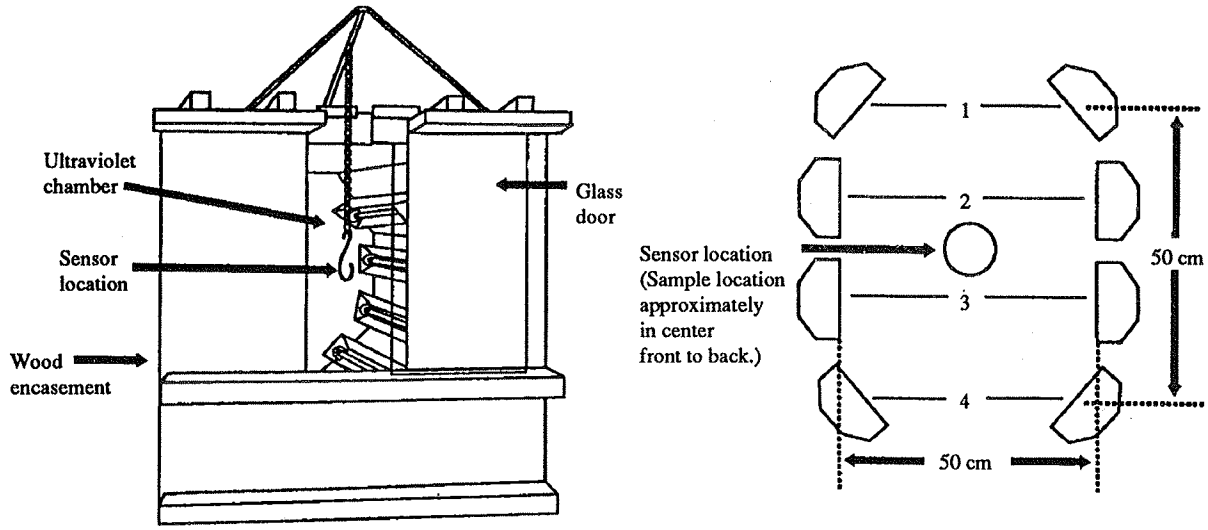

Figure 1. Ultraviolet chamber.
a. Actual drawing of chamber.
b. Shematic of ultraviolet chamber showing arrangement of lights around sample to be treated.

UV light, allowed access to the cabinet.

Experiment 1. Effect of Ultraviolet Radiation on the Color of Chicken Skin

Refrigerated chicken breast halves were obtained from a local processor. Twenty halves were placed in plastic freezer bags and held at 4 C. These served as controls. An additional twenty halves were each subjected, individually, to a one minute treatment of UV radiation (UV dose 82,560 $\mu Ws/cm^2$), then placed in freezer bags and held at 4 C. Previous experiments with UV light treatment of *Salmonella* inoculated on agar plates suggested that the above UV light intensity and treatment time were optimal to achieve the desired germicidal effect. Five halves from each group were removed on days 0, 3, 7, and 10, and Hunterlab color values (L, a, b) were determined. Four color readings were determined separately on each leg and breast.

UV radiation at a dose of 82,560 $\mu Ws/cm^2$ had a slight effect on color. The UV treatment had an effect on L values for legs, as the untreated legs were slightly lighter in color. No other differences in redness or green discoloration were seen between treated and untreated legs or breasts.

Experiment 2. Effect of Ultraviolet Radiation on Rancidity and Psychrotrophic Bacteria

Twenty whole, fresh broiler chickens from a commercial processor were split into approximately equal halves. Twenty of the halves were placed in plastic freezer bags and held at 4 C. These served as controls. The remaining 20 halves were each subjected to a one minute treatment of UV radiation (UV dose 82,560 $\mu Ws/cm^2$), placed in freezer bags, and held at 4 C. Five halves from each group were assayed on days 0, 3, 7, and 10 for milligram malonaldyhyde/kilogram meat via the 2-thiobarbituric acid (TBA) method. Carcass psychrotrophic bacterial counts were determined on the same days. The experiment was repeated twice.

The TBA values were significantly different for UV-treated versus untreated chicken halves over the 10-day storage period at 4 C and were actually reduced on all days except day 7. Continuous UV treatment has been reported to increase rancidity in fatty meats, but it appears from this experiment that a single low dose UV exposure may not have this effect.

Slight differences in psychrotrophic bacterial counts were seen when UV-treated versus untreated chicken halves were compared; however, an extension of shelf life in UV treated poultry carcasses was not observed. By day 7, both treated and control halves demonstrated surface slime, foul odor, and yellow discoloration.

Experiment 3. Effect of Ultraviolet Radiation on *Salmonella* Recovered From Chicken Carcasses

Sixteen broiler chicken halves were purchased from a commercial processor. Four liters of cold, sterile .1% peptone broth were inoculated with a dilution of nalidixic acid-resistant *S. typhimurium* to achieve a final concentration of 1.2 x 10^6 cfu/mL. Fourteen chicken halves were inoculated with the test bacteria by immersion into this dip solution for 60 seconds. Each half was then allowed to drain on a sterilized test tube rack for 2.5 min on each side (total 5 min). Two halves remained un-inoculated and served as negative

controls. Seven chicken halves were then UV-treated by suspending them one at a time in the center of the UV cabinet (UV dose 86,400 $\mu Ws/cm^2$) for one minute. The remaining seven inoculated halves were not UV-treated and served as positive controls. *Salmonella* were recovered from the chicken halves using a low-volume water rinse technique. Serial dilutions were made from the rinse solution and spread-plated in duplicate onto McConkey agar and tryptose soy agar plates, both containing 100 ppm nalidixic acid. The plates were then incubated at 37 C. Bacterial colonies per plate per dilution were determined both at 24 hours and at 48 hours. Selected bacterial colonies were submitted to a veterinary diagnostic laboratory for organism identification.

Salmonella organisms have been shown to be susceptible to UV radiation on agar plates. Three log reductions (99% kills) are achievable when perfectly smooth surfaces are UV-treated with the appropriate UV intensity and length of time. In this study, UV radiation resulted in a 61% reduction in *Salmonella* on both types of agar media. The reason for this lower kill rate is probably because chicken carcasses do not have smooth surfaces, and the skin is lined irregularly with numerous feather follicles. It is possible that bacteria may have entered pores left by feather follicles, becoming inaccessible to UV light. Unlike gamma irradiation, UV radiation has no penetrating ability and therefore would have no effect on bacteria located deep within tissues. UV light treatment would not be recommended as the sole method to reduce carcass contamination during processing. Combined with other bacterial reduction techniques during processing, however, it may have commercial applications for the processing industry.

Utilization of Spent Fowl

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R. W. Mandigo
M. A. Hanna

For many years the poultry industry has experienced problems in finding a suitable market for spent fowl. Leghorns, which are commonly used for laying purposes, have a poor meat yield and many processors are finding it more profitable to use younger birds, and the labor to debone spent fowl as well as the small yield of edible meat, has not been profitable. Mechanical deboning of the whole eviserated carcass may offer a means for utilizing spent fowl.

Mechanical Deboning — Froning and Johnson (1973) mechanically deboned whole eviscerated spent fowl and found that the composition was quite comparable to that from hand-deboned spent fowl (Table 1). These values include the attached skin. Froning and Johnson (1973) further observed that centrifugation of the mechanically deboned spent fowl meat reduced the fat and heme pigment content of the meat. The mechanically deboned spent fowl had excellent emulsification properties, when compared to the hand-deboned source (Table 2). Both emulsifying capacity and emulsion stability of mechanically deboned spent fowl were comparable to hand-deboned sources. In other words, mechanically deboned spent fowl would perform well in

Table 1. Analyses of mechanically deboned spent fowl.

Treatment	Protein %	Moisture %	Fat %
Hand-deboned spent fowl	14.3	61.6	22.1
Mechanically-deboned spent fowl	13.9	65.1	18.3

Table 2. Emulsification characteristics of mechanically deboned spent fowl meat.

Treatment group	Emulsifying capacity ml/12.5g meat	Emulsion stability per 100g emulsion			Cooking loss %
		Gel-water	Solids	Fat	
Hand-deboned spent fowl	145	13.9	0.8	4.9	25.8
Mechanically-deboned fowl	146	15.8	2.0	4.1	27.1

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emulsified products, such as frankfurters. Further work showed that mechanically deboned spent fowl meat would also hold up well in frozen storage, providing the carcass is chilled in 6% polyphosphate prior to deboning (Froning, 1973). In fact, no rancidity was observed in polyphosphate-treated mechanically deboned spent fowl after eight weeks of frozen storage.

Work in the early 70's indicated that mechanically deboned spent fowl had potential in further processed meat products, with a texture comparable to that obtained from hand-deboned sources. Today's mechanical deboners are much improved and likely would produce a superior product. In fact, some deboners today are producing a meat product with textural attributes similar to that of intact muscle.

Extrusion Technology — Since mechanically deboned spent fowl meat has some good functional characteristics, it may be possible to extrude and mechanically texturize deboned spent fowl meat into a value-added product. The extrusion and texturization of poultry products was reviewed by Maurer (1979). Lampila *et al.* (1985) formed mechanically deboned turkey into fibrous chunks by cold extruding strands and heat-setting the strands to simulate meat fibers. Turkey roasts made from the heat-set fibers had improved textural properties. Twin screw extruders have been utilized to texturize mechanically deboned chicken broiler meat (Megard et al., 1985).

Recently, work has been completed in our laboratory on use of extrusion technology for adding value to mechanically deboned spent fowl meat. Mechanically deboned whole, carcass spent fowl were supplied by ConAgra Foods Inc. in Omaha. In the first study, the Wenger twin screw extruder was utilized to form simulated meat fibers, which were further incorporated into chicken nuggets. Formulations included various treatments groups (3, 10, or 20% soy isolate, 5% waxy starch; or 3% egg white solids). All formulations also contained 2% chicken broth. The various formulations were extruded at temperature of 79°C and a barrel speed of 74 rpm. Generally, the extrusion-formed nuggets were well-accepted by the panelists. Extruded nuggets had an appearance analagous to nuggets made from intact muscle. Spun soy fibers, in combination with the extruded mechanically deboned spent fowl, appeared to be preferred.

In another study, mechanically deboned spent fowl was extruded at a temperature of 220°C and a barrel speed of 440 rpm to produce an edible snack product similar to corn curls. These can be flavored as desired (i.e. cheese, chicken, bacon, etc.). Although these products were less well accepted by the panelists, it is felt the snack approach still has some feasibilty. The success of this extruded snack likely relates to a suitable flavor combination.

Utilization of extrusion technology should have future application to spent fowl meat, which is an excellent source of muscle protein that should not be under-utilized. It makes sense to use this meat source as an ingredient in foods, rather than as pet or animal feed. Processing technologies are now available to improve utilization of meat sources, including spent fowl. The poultry processing industry should be pursuing these options for efficient use of this meat ingredient.

Opportunities for Poultry Byproducts in Beef Cattle Nutrition

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Daniel W. Herold

In ruminant diets, protein available for absorption at the small intestine is the sum of the microbial protein synthesized in the rumen and the feed protein which escapes ruminal digestion. Microbes present in the rumen require available nitrogen for microbial growth and protein synthesis. This rumen-available nitrogen is supplied by feed proteins that degrade in the rumen, as well as non-protein nitrogen sources such as urea.

Microbial protein alone, however, may be inadequate to meet the protein needs for high rates of production, such as rapidly growing calves or cows in

peak lactation. The protein requirements of these animals can be met by feed proteins which escape ruminal degradation (escape protein). Providing additional protein to the small intestine as escape protein will increase production in such cases, provided the ruminant is able to digest the escape protein in the small intestine and the escape protein provides the amino acids that the animal needs.

Hydrolyzed feather meal (FTH) and poultry byproduct meal (PBM) are two byproducts of the poultry industry which offer potential sources of escape protein for ruminants. Feathers, which are nearly all protein, must be hydrolyzed with steam and pressure to improve digestibility. Feather meal has been determined to be a good source of escape protein for ruminants, and, if hydrolyzed, is 95 to 100% digestible in the small intestine. The only problem with FTH is the relatively poor amino acid array.

In an attempt to improve the amino acid array of FTH, research was conducted to evaluate the effects of blood meal (BM) addition to FTH. The amino acid array of BM, an excellent source of escape protein, may compliment the amino acid deficiencies of FTH, thereby improving protein efficiency.

Poultry byproduct meal consists of the ground, rendered parts of carcasses of slaughtered poultry such as heads, feet, and viscera. With further processing of poultry, such as mechanical deboning, more bones are being produced and rendered as PBM. In addition to escape protein, PBM high in bone (ash) content offers an excellent phosphorus source. Poultry byproduct meals high in bone (ash) content are lower in value than low-ash materials, which are used to a large extent in the pet food industry. Other rendered products, such as meat and bone meal, (MBM) are good sources of escape protein and therefore PBM may also be a good source of escape protein. The objective of this study was to evaluate poultry byproduct meal and meat and bone meal as escape protein sources for growing calves.

Procedures

Growth Trial 1. One hundred growing calves (529 lb) were fed for 112 days to evaluate the protein value of urea, soybean meal (SBM), FTH, BM, and a 50:50 protein combination of FTH and BM. Protein efficiency, calculated as gain above the urea control vs. natural protein intake, was plotted for each treatment using the slope ratio technique. The basal diet contained 50% ground corncobs, 40% corn silage, and 10% supplement. Calves were individually fed (at equal percent of body weight) once daily with Calan electronic gates. Calves were implanted with Compudose and initial and final weights were the average of three consecutive day weights taken before feeding.

Growth Trials 2, 3 and 4. Four samples of MBM and six samples of PBM varying in ash content and origin of manufacture were obtained from various commercial renderers and used as protein sources for growing calves. In each of three growth studies, diets of 44% sorghum silage, 44% corncobs, and 12% supplement was fed to 60 individually fed crossbred steers (568, 530, and 506 lb for Trials 2, 3, and 4, respectively). Steers were supplemented with 4 of the 10 protein sources along with urea in each of the three studies. Protein sources were fed at 30, 40, 50, and 60% of the supplemental N, with urea supplying the remainder. Therefore, regardless of the assigned level, all calves were consuming a ration DM containing 11.5% CP. Calves were individually fed (at equal percent of body weight) once daily with Calan electronic gates. Weight data were collected before feeding on three consecutive days at the beginning and end of each 84-day trial. Protein efficiency, calculated as gain above the urea control vs. natural protein intake, was plotted for each treatment using the slope ratio technique.

Digestion Study. A lamb digestion trial was conducted to determine the relative digestibility of these same protein sources plus SBM and a urea control. Lambs were individually fed a basal diet of corncobs and alfalfa supplemented with one of the protein sources. Diets were fed at a constant percent of body weight for a 14-day pre-feeding and a 7-day fecal collection period. Feed, feces, and orts were dried in a forced-air oven and analyzed for dry matter and protein.

Protein Degradation Trial. An in-situ dacron bag trial was conducted to determine the escape protein values of these same samples of MBM and PBM. A grass hay diet was fed to two mature ruminally cannulated steers. About four grams of each protein

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Table 1. Composition of soybean meal (SBM), feather meal (FTH), blood meal (BM) and poultry byproduct meal (PBM).

Protein source	Crude protein	Escape protein[a]	Digest[b]	Methionine[c]	Total Sulfur[c]	Lysine[c]
SBM	49.0	26	100	1.37	2.90	6.53
FTH	91.0	73	96	0.64	4.44	1.84
BM	89.8	90	100	1.27	2.51	8.95
PBM 1	58.5	34	89	1.45	2.26	5.03
PBM 6	66.0	34	90	1.42	2.41	4.62

[a]Escape protein determined as percentage of protein remaining after 12 hours of ruminal incubation in dacron bags.
[b]Total tract digestibility determined in lambs.
[c]Amino acid composition as percent of crude protein.

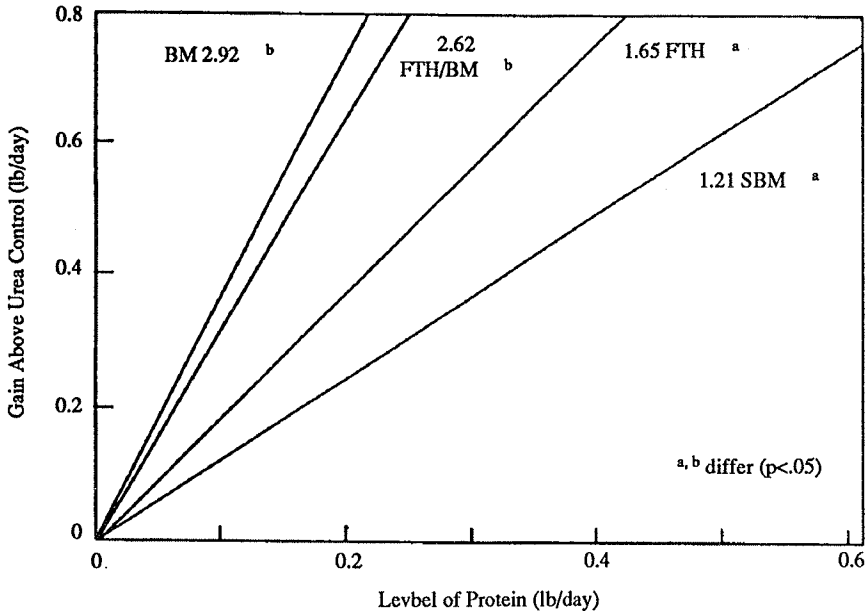

Figure 1. Protein efficiency of calves fed soybean meal (SBM), feather meal (FTH) and blood meal (BM).

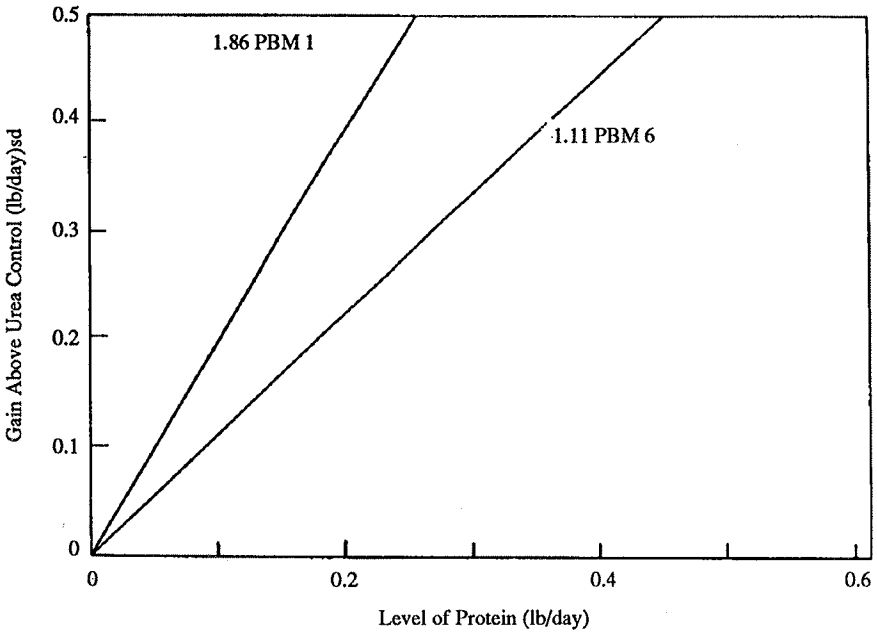

Figure 2. Protein efficiency of calves fed poultry byproduct meals (PBM).

source were placed in 2 x 5 inch dacron bag (50 micron-pore size). Each feedstuff was placed in four bags within each steer. Bags were suspended in the rumen for 12 hours. After removal from the rumen, bags were washed to remove contamination. Total nitrogen was determined before and after ruminal digestion to determine escape of each protein source. Amino acid analysis was completed to determine composition of the protein before and after ruminal digestion.

Results

Growth Trial 1. The urea control calves gained .83 lb/day, while the maximum gain due to protein supplementation was 1.62 lb/day. The most efficiently used protein sources (Figure 1) were BM and FTH-BM, compared to SBM and FTH ($P<.05$). A possible complementary effect was observed when BM and FTH were fed together, as the protein efficiency for the mixture was higher (2.62) than the average of BM and FTH (2.07). This was likely due to BM supplying lysine while FTH supplied sulfur amino acids. Previous research has shown protein efficiency similar for BM and FTH when FTH contained 10% blood. The 10% blood addition may have been sufficient to meet the lysine requirement of growing calves.

Growth Trials 2, 3, and 4. The urea control calves gained .74 lb/day, while the maximum gain due to PBM supplementation was 1.40 lb/day. Cattle fed PBM supplements gained 0.32 lb/d more than those fed the urea control. Protein efficiency did not differ among PBM treatments ($P>.10$), ranging from 1.11 to 1.86 (Figure 2). The higher daily gains indicate PBM supplies escape protein to supplement the inadequate ruminal microbial protein.

Digestion Study. The N digestibilities of the PBM sources were not significantly different ($P>.10$), ranging from 84.6% to 93.2% indicating PBM is highly digestible by lambs.

Protein Degradation Trial. Crude protein content of PBM ranged from 52% to 66%, while in-situ analysis found that escape protein values for PBM sources ranged from 32% to 40%. Escape crude protein was moderately correlated ($R^2=.65$) with protein efficiency, but had a negative slope. Like all animals, ruminants have an amino acid requirement, rather than an escape protein requirement, suggesting escape crude protein may not be the best indicator of protein quality.

Amino acid contents of the PBM sources after the 12 h ruminal in-situ

digestion were determined and digestible escape amino acid contents (% of crude protein) calculated for each protein source. To determine the first limiting amino acid, digestible escape amino acids were regressed on the protein efficiency values. Metabolizable methionine was the amino acid best correlated (R^2=.37, slope=2.2) to protein efficiency, whereas other amino acids were either poorly correlated or had negative slopes. These data indicate that protein quality of PBM for ruminants is limited by the amount of digestible escape methionine it contains. Added methionine which escapes ruminal digestion may increase protein efficiency.

Feather meal is a high-escape, economical protein source for ruminants. Because of a poor array of amino acids, it is best if combined with a high lysine escape protein source. Blood meal shows a good complementary effect with FTH, but BM is quite expensive. Another, less-expensive source of complementary amino acids would be worth investigating. Poultry byproduct meal is an escape protein source which appears adequate in lysine but deficient in the sulfur-containing amino acid methionine. Poultry byproduct meal represents an option for a relatively high-escape protein source to be blended with FTH. This blended product could contain a good array of amino acids, a high crude-protein content and an appropriate mineral content to be an excellent ruminant escape protein source. Current research with PBM is attempting to determine the complementary effects on protein efficiency when fed in combination with FTH, with or without added ruminal escape methionine and lysine. Such research benefits the cattle producer by optimizing production, as well as the poultry producer by creating a market for poultry byproducts.

Renovation of F Building, Poultry Research Complex

Mary M. Beck
Sheila E. Scheideler

When budget cuts at UNL in 1992 forced the closing of most of the poultry research complex, including its feed mill and six or seven production-type buildings, the decision was made to renovate one building for multiple use by scientists in the program. Estimated at ~$100,000, the funds for this project came from a revolving account that had grown over the years from the sale of eggs and birds. Construction began in the fall of 1993 and birds were moved in April, 1994.

The "F Building" originally housed the complex office, incubator room, egg-processing room, a small feed-mixing room, two environmental chambers, two large bird rooms, and a classroom. In order to accommodate a wide variety of proposed research activities the interior was essentially gutted and all load-bearing walls were removed and repositioned. The somewhat reconfigured egg processing and incubator rooms were retained and connected in the north end of the building. The restroom, located in the egg room, is now handicapped-accessible.

A small storage room connects the incubator room with the bird room immediately to the south. This room, spanning the width (50 feet) of the building is 25 feet across and will house laying hens in two large, floor pens. The pens will be developed into aviary-type housing for research involving both behavior and long-term calcium studies.

Access to the next room to the south is possible only from the outside; no doors connect it with rooms on either side. This large room (also 25x50 feet) houses laying hens in a multi-tier industry prototype (Big Dutchman) layer unit equipped with manure drying belts. The hens housed in this room will be primarily involved in nutrition studies.

The south end of F Building contains a very large (50 feet wide x 93 feet long) room that will contain, at various times, broilers or turkeys in moveable floor pens. Water lines and lighting will accommodate pens of various sizes. The room is also suitable for housing additional layer units as the need arises.

The Animal Science Department retained use of the old feedmill on the site for storage purposes. All other building except the former layer house, will be demolished; the layer unit will be retained by the University for storage. The entire corner of the property, including F Building, the mill, and extending to the intersection of 39th and East Campus Loop, will be enclosed by plantings to limit vehicle access near the birds.

We appreciate the Nebraska Poultry Industries assistance in obtaining modern poultry equipment for this facility.

Beneficial Effects of Dietary Oats on Layer Production

Sheila E. Scheideler
Mary Beck
Tami Brown
Kamel Mahmoud
Jihad Douglas

Dietary oats are frequently used in pullet rations but are rarely used in least-cost layer rations, despite their excellent nutritional value. Oats provide high-quality energy and protein to the birds with a unknown fiber effect. Most poultry nutritionists have assumed dietary fiber will inhibit the layer's feed intake and consumption of nutrients. However, there could be some possible health benefits of including a soluble fiber in poultry rations, similar to those reported in human literature. Several reports from European literature suggest less coccidiosis in layers when the gizzard is challenged with whole grains (Misset, 1993). They theorized the gizzard acts as a kind of natural defense mechanism against coccidiosis by better mechanical destruction of oocysts, sporocysts, or sporozoites.

The objectives of this research over this past year have been to test the laying hen's response to various levels of dietary whole oats in the ration, as well as the effect of the presence of whole oats on gizzard size. Two experiments have been conducted. Experiment 1 involved feeding four levels of whole oats (0, 2.5, 3.75 and 5.0%) in isocaloric and isonitrogenous phase 1 layer rations to Dekalb Delta pullets from 25 to 41 weeks of age. Each diet was fed to eight replicate pens with four hens per pen. Results of the experiment are shown in Table 1.

Table 1. Oats Study One. Production Results (Averages from 25 to 41 weeks of age)

Diet	Egg production (%)	Feed cons. (g/hen/day)	Body wt. gain (g)	Egg weights (g)
Control	84.0	91.6	84.3	56.8
2.5% Oats	89.3	95.5	100.5	57.7
3.75% Oats	85.7	94.2	126.6	57.7
5.0% Oats	87.4	92.7	61.0	57.6

The inclusion of dietary oats had a positive effect on level of egg production and egg weights across all three dietary inclusion levels. However there was not a linear response to increasing the amounts of oats. In fact, the greatest increase in egg production (5.3%) came from the lowest level of supplemental oats (2.5%). The hens on the 2.5 and 3.75% oat diets also gained more weight than the controls, indicating the bulkiness of the diets did not prevent adequate energy intake. All oats were added to the diets as whole oats and examination of fecal material showed very little undigested whole oats and relatively good solubilization of the oats fiber. A sample of three hens per diet showed that % gizzard size significantly increased with the presence of dietary oats (1.46, 1.56, 1.55 and 1.55% for the control, 2.5%, 3.75% and 5.0% oats diets respectively). Again, there was no linear response to increasing oats above the 2.5% level.

A second experiment was conducted with Babcock B300 at 26 weeks of age to test the effects of dietary oats on the bird's response to a heat stress. Unfortunately, a number of birds were lost to a equipment malfunction. The surviving birds were kept on a 2.5% oats ration until 35 week of age. At that time, the oats birds had 1.67% gizzard weight on 1,647 g bird versus 1.52% gizzard weight on a 1,599 g bird. There was no difference in % egg production with the small number of birds left on the feed (16/diet) after the heat stress.

Preliminary in-vitro studies of calcium transport in four hens from each of experiment 2 treatments indicate that dietary oats may enhance the large intestine and cecum's ability to transport calcium. The most often studied site of calcium transport is the duodenal loop; however, human literature has reported a positive effect of dietary fiber on nutrient uptake in the large intestine. Our preliminary data indicate the hen does have the ability to transport calcium in the large intestine and the cecum, and that such transport may be enhanced by the presence of dietary oat fiber. More research in this area is planned for the coming year.

In conclusion, enough data have been gathered to suppport the theory of a positive benefit of dietary whole oats in hen rations on egg production and gizzard function. Many questions remain to be answered about the role of dietary fiber, including whether or not other fiber sources would have the same effect.

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Undergraduate programs for Animal Science majors and for other students in the College of Agricultural Sciences and Natural Resources help develop the student's capability to cope with problems of Nebraka's livestock, poultry, and meats industries. To prepare students for positions in management, animal production, processing, teaching, or research, specializations are designed by the student and the adviser in several areas. Examples of possible areas of specialization include the following:

Species	Programs	Disciplines
Cattle	Business	Genetics
Beef Cow/calf	International	Meats
Dairy	Management	Nutrition
Feedlot	Production	Physiology
Horse	Range	
Poultry	Science	
Sheep		
Swine		