

PRESERVATION AND NUTRITIONAL VALUE OF CAGED LAYER WASTE
TREATED WITH DIFFERENT PRESERVATIVES

by

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Thesis submitted to the Faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

in

Animal Science

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March, 1987

Blacksburg, Virginia

DEDICATION

This thesis is dedicated to the memory of my father.

ACKNOWLEDGEMENTS

The author would like to express his appreciation to
for his guidance, assistance, friendship
and patience without which this project could not have been
completed.

Appreciation is also extended to
, and for serving on the
author's graduate committee.

The author would especially want to thank
and for their technical assistance
with various parts of the laboratory analyses.

The cooperation and friendship of his fellow graduate
students are deeply appreciated.

Most of all the author would like to thank the moral
and economic support of his sister and brother-in-
law, , which made this graduate program
possible.

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Chapter I

INTRODUCTION

Animal waste disposal is a major problem concerning the livestock industry. One role of animal nutritionists is the constant search for new sources of nutrients for which animals would not be in competition with humans. The recycling of animal waste as a feedstuff will result in availability of a new source of nutrients which are not used by humans, a decrease in animal production costs and a partial solution for animal waste disposal.

Because of its high N content poultry waste constitutes a potential source of protein for the livestock industry. A substantial portion of this N is in the form of non-protein nitrogen (NPN), contributed mainly by uric acid and NH_3 . The high content of NPN necessitates recycling poultry waste through ruminants rather than non-ruminants, due to the ability of ruminants to utilize NPN.

Fresh caged layer waste contains approximately 70% (w/w) water and several microorganisms which can lead to undesirable fermentation of the material unless controlled carefully. Dry heating, autoclaving, fumigation and ensiling have been evaluated as possible solutions to the fermentation problem, but some of these methods are

impractical for livestock producers due to high cost and/or non-availability of necessary equipment.

This study was conducted to evaluate certain chemical agents for the preservation of fresh caged layer waste. The preserved material was used as a diet component in a ruminant diet in order to evaluate its potential as a N source.

Chapter II

LITERATURE REVIEW

Poultry waste can be classified according to source as either poultry litter or caged layer waste. Poultry litter is the waste consisting of bedding material (wood shavings, peanut hulls, cotton seed hulls, ground corn cobs, etc.), excreta, wasted feed and feathers, produced by floor-reared birds. Caged layer waste is composed of excreta, wasted feed, broken eggs and feathers collected beneath wire cages in which the hens are kept.

Nutritive Characteristics of Caged Layer Waste

The nutritive value of the excreta varies greatly according to production practices and waste management.

Nitrogen. Caged layer waste has a high crude protein content, averaging 28 to 32%, dry basis, but only 11% true protein (Bhattacharya and Taylor, 1975). Approximately 50 to 60% of the total N is NPN (Evans et al, 1978).

The N content of the excreta varies with diet and stage of production of the birds and management of the waste (Evans et al, 1978). Storing wet caged layer waste has resulted in N losses of up to 40% in a 98-d period (Flegal et al, 1972). The greater losses were observed in waste from hens fed a high-protein diet. The different levels of

uric acid excreted by the birds largely accounts for the difference in total N of the excreta (Evans et al, 1978).

Uric acid was found to be a N source utilized by the rumen microflora (Belasco, 1954). The release of bacterial uricase may be induced within hours of feeding uric acid to ruminants, and a quick release of NH_3 can be achieved after a 3-wk adaptation period. The release of NH_3 is slower with uric acid than with urea, which suggests that uric acid is a NPN source with a more favorable utilization pattern than urea (Oltjen et al, 1968). When fed as the only source of N, uric acid had an apparent digestibility of 68% (Oltjen and Dinius, 1976).

Brugman et al (1964) reported an apparent digestibility of 78% for crude protein of laying house poultry excreta.

Energy. Pryor and Conner (1964) reported gross energy values ranging from 3,220 to 4,480 kcal/kg for dried poultry waste from chickens fed different diets. Brugman et al (1964) reported a gross energy value of 3.6 kcal/g for laying house poultry litter and a digestibility of 59% for energy, when fed to bulls.

Bhattacharya and Fontenot (1966) determined the gross energy contents of peanut hull and wood shaving poultry litters, of 3,862 and 3,748 kcal/kg, respectively, dry basis. The calculated energy digestibilities for these

litters were 63.9 and 64.2%, respectively. The inclusion of litter in the diets decreased energy digestibility in proportion to the amount of litter incorporated. Kind of base in the litter (wood shavings and peanut hulls) had no significant effect on the energy digestibility of the diet.

Metabolizable energy of dehydrated layer waste for sheep ranged from 2.22 mcal/kg (Parizi-Bini, 1969) to 1.79 mcal/kg (Lowman and Knight, 1970). According to Pryor and Connor (1964) dried poultry waste has 1.1 mcal/kg of metabolizable energy for poultry. Tinnimit et al (1972) reported 52.3% of total digestible nutrients for dried poultry waste fed to sheep.

Dried poultry waste has 1,100 kcal/kg of metabolizable energy for poultry, according to Pryor and Conner (1964) or approximately 6% of the metabolizable energy content of corn for hens according to Rinehart et al (1973).

Minerals. Caged layer waste is high in ash content. Some of the ash sources are broken egg shells and feathers, commonly found on the waste, but most of it results from the high Ca fed to the birds. Bull and Reid (1970) reported ashes values as high as 28%.

The two main minerals contributing to this ash content are Ca and P. Calcium content has ranged from 6.07% (Brugman et al, 1964) to 8.8% (Bull and Reid, 1971), dry

basis, and P from 1.77% (Brugman et al, 1964) to 2.5% (Bhattacharya and Taylor, 1975). The NRC (1983) reported values of 22, 7.08 and 1.74% respectively for ash, Ca and P content in cage layer waste. Tagari et al (1981) reported that poultry litter had 39% net P availability and 38% net P utilization; these values are 60.9% and 60.3% of those for dicalcium phosphate. In that study the N digestibility was not affected by the level of P in the diet, but there was a high correlation between N retention and net P availability and utilization. Cooke (1985) reported a trend for higher P absorption from broiler litter than from dicalcium phosphate, perhaps as a result of a better utilization of the P.

Microbiology of Poultry Waste

Schefferle (1965) found 172 strains of bacteria capable of decomposing the uric acid in poultry waste, which results in production of NH_3 or urea, giving the waste the characteristic ammoniacal smell and high alkalinity. One-fourth of the bacteria found were responsible for decomposing the uric acid to urea by initial oxidation and hydrolysis; other bacteria, mainly, coryneform and micrococci are responsible for hydrolyzing the urea to form ammonia.

Halbrook et al (1951) suggested that water and feed are the sources of the gastrointestinal tract flora, since he found the microflora of hen excreta and litter were similar. Kraft et al (1969) found higher densities of salmonella in fresh excreta from caged birds than in built-up litter, suggesting that cage housing may promote the shedding of salmonella. On the other hand, Schefferle (1965) found that the counts for viable bacteria were lower in poultry droppings than in built-up litter, which may result from multiplication of the bacteria after excretion. Lovett et al (1971) confirmed Schefferle's findings when he found that older litter had higher microbial densities, although coliforms and *E. coli* remained mostly stable after 1 wk. Alexander et al (1968) found that storage of the litter for 2 wk will destroy salmonella. *Escherichia coli* has been used as an indicator of microbial contamination of litter, but Messer et al (1971) found that although salmonella is not highly resistant to heat in poultry litter of normal moisture content, it is still more resistant than *E. coli* to autoclaving. Lovett (1972) found the same toxigenic fungi in poultry litter as in poultry feed.

Processing Methods

Dry Heating. The use of dry heat to preserve broiler litter resulted in significant losses of crude protein (N and NPN), amounting up to 13.9% of the total N (Fontenot et al, 1971). Coliforms were completely eliminated by the use of dry heat for 20 min at 150 C at a depth of .6 cm., but again significant amounts of N were lost (Caswell et al, 1975). When fresh cage layer waste was dried to 50, 70 or 80% DM, drying resulted in significant N losses regardless of the DM level achieved (Evans et al, 1978).

Treating broiler litter with 1 N sulfuric acid at the rate of 30 ml/100 g to lower the pH prior to dry heating resulted in lower N losses than when dry heating without acid treatment, but the digestibility of the components of the diets containing the processed material was lowered (Harmon et al, 1974).

Autoclaving. Harmon et al (1974) processed broiler litter by autoclaving it under a steam pressure of 1.06 kg/cm² for 40 min which resulted in N losses of 10.8%. Caswell et al (1975) concluded that autoclaving at a steam pressure of 1.05 kg/cm² at a depth of .6 cm for 10 min or longer will reduce total bacterial counts to acceptable levels. No loss of total N was reported by autoclaving up

to 20 min, but losses of uric acid and ammonia N started after 15 min. El Sabban et al (1970) reported that autoclaving caged layer waste under steam pressure of 2.11 kg/cm² for a minimum of 30 min reduced the digestibility of the crude protein.

Fumigation. Messer et al (1971) reported that fumigation with ethylene oxide reduced but did not eliminate the bacterial population from poultry litter. Caswell et al (1975) reported that fumigation with ethylene oxide should last more than 30 min in order to reduce bacterial count to an acceptable level.

Deep Stacking. The process of deep stacking consists of stacking the waste material in an open shed, which results on an anaerobic environment for the inner part. Dana et al (1978) deep stacked wood shavings broiler litter at a depth of 1.55 m for a period of 42 d. An initial increase on temperature was observed, followed by a decrease by the end of the preservation period. Deep stacking resulted in the elimination of total and fecal coliforms, salmonella and shigella, but not proteus.

Aerobic Stabilization. This process involves aerobic fermentation by thermophylic bacteria that is closely controlled with the aid of air blowers, vents and

instrumentation to keep a proper environment. Aerobic stabilization of laying-hen manure has resulted in a apparent increase in quantity and quality of amino acids, possibly from an increase in the microbial mass and a destruction of total solids (Martin and Loehr, 1983). Use of aerobically fermented fresh poultry manure up to a level of 20% of the diet (wet basis) of laying hens resulted in excellent hen livability and egg production (Naber, 1982).

Ensiling. Saylor and Long (1974) found that ensiling fresh caged layer waste (72% moisture) alone resulted in putrefaction of the silage, therefore, waste should be ensiled at lower DM levels and/or in combination with other materials in order to achieve desirable fermentation parameters and to enhance the nutritional characteristics of the silage.

Caswell et al (1978) ensiled broiler litter at moisture levels of 15.6, 20, 30, 40 and 50%. A 107% increase on lactic acid was observed at the 40 and 50% moisture levels. The presence of molds in the silage was detected at the 50% level.

Vezev and Dobbins (1975) ensiled a mixture consisting of 50% corn, 20% floor litter, 30% caged layer manure, with the addition of dried molasses, water and *Lactobacillus acidophilus*. They concluded that the amount of water added

should be sufficient to obtain 40 to 50% moisture in order to attain the best fermentation patterns.

Harmon et al (1975) ensiled corn forage with broiler litter. The broiler litter supplied 15, 30 and 45% of the total DM of the ensiled mixture. A direct relation was observed between broiler litter addition and crude protein and ash contents of the silage. Coliforms counts were lowered by the ensiling process. Therefore, ensiling waste with forage increased the nutritional characteristics of the product and reduced potential hazards by reducing the number of pathogens in the litter.

Ensiling broiler litter with corn grain (1:2) resulted in an increase of the crude protein content of the mixture, but total N was not changed by ensiling. Bacterial counts were reduced to 8.5% of the initial count after fermentation (Caswell et al, 1977).

Chemical Agents as Preservatives

Several chemical agents have been used in an attempt to stop the decomposition of high moisture organic material. Beutling (1983) used sodium metabisulfite at a rate of 2% (w/w) in homogenized slaughter house offal, which allowed preservation for 8 to 10 d without any cooling. The use of sodium metabisulfite (.3 and .45% of the DM) during the

ensiling of lucerne helped the preservation process by preferential inhibition of undesirable fermentative changes, presumably by reducing lactate producing and lactate metabolizing bacteria in the silage (Lanigan, 1961).

Flaked paraformaldehyde was used by Seltzer et al (1969) on the litter of poultry houses to control ammonia odors. This agent liberates formaldehyde gas as it decomposes. They observed an inhibition of the odor of NH_3 gas and an antimicrobial action which resulted in a reduction of the N losses from the litter and an increase on egg production as a result of less polluted environment. Lindahl (1974) added 1 ml of 37% formaldehyde to 4 kg of reconstituted ewe milk replacer which retarded bacterial growth and prevented souring of the milk for 24 h at 25 C, 48 h at 17 to 18 C, and 72 h at 7 C. The lambs readily consumed the formaldehyde treated milk replacer and showed no digestive disturbances.

Singh-Verna (1974) used .65% (w/w) formic propionic, acetic and sorbic acids for the preservation of soybean, mixed feed and 30% moist barley and wheat. Preservation from the microbiological point of view was achieved for as long as 2 mo, formic acid being more active than the other acids. Woolford (1984) found that formic acid, sodium diacetate, propionic acid, ammonium isobutyrate and tributyl

phosphate were effective in reducing the microflora of moist hay and that their antimicrobial properties were enhanced under slightly acid conditions. In another study Woolford (1974) found that salts of formic, acetic and propionic acids and glutaraldehyde showed antimicrobial action against coliforms, clostridia and bacilli when used as silage additives, therefore, creating a desirable fermentation. Yu et al (1975) was able to reduce fungal counts on alfalfa hay by 40% when using .4% propionic acid or .5% ammonium isobutyrate. Further reduction (75%) was achieved when the doses were doubled. Paster (1979) successfully controlled fungal population in poultry feed (13% moisture) stored for 53 d under summer conditions using .3% (w/v) propionic acid or .5% calcium propionate.

Smith et al (1978) evaluated mixtures of 20% acetic-80% propionic acids; 14% acetic - 56% propionic acids - 30% formaldehyde; and formaldehyde alone, each at .25%, .5% or 1% (w/w) as preservatives for caged layer excreta. All three preservatives were equally effective in reducing N losses. At the .5% level none of the preservatives maintained an acceptable quality in terms of physical and nutritive value beyond 7 d. At the high level (1%) the three treatments were relatively acceptable in maintaining an acceptable quality for a period of 14 d. The acetic-

propionic treatment appeared to be the most effective, particularly at the high rate. Narasimbalu et al (1981) evaluated the effect of .01%, .05%, .2% and .5% (w/w) sodium metabisulfite, calcium hypochlorite, sodium hypochlorite, propionic acid, tannic acid and formaldehyde on the microbial population of broiler litter and caged layer waste. A significant dose-response effect was observed with all chemicals except tannic acid. In the broiler litter, sodium hypochlorite and sodium metabisulfite were the most effective against aerobic bacteria. Sodium hypochlorite was the most effective against coliform bacteria. Sodium metabisulfite and calcium hypochlorite were the most effective in reducing fungal counts. Formaldehyde and tannic acid depressed microbial counts to a greater extent in layer waste than in broiler litter, while sodium metabisulfite and calcium hypochlorite were inactive in layer waste.

The use of high levels of formaldehyde as a preservative may reduce energy digestibility, protein solubility and digestibility through cross-linking of protein and may also reduce feed intake (Smith et al, 1978). Barny et al (1972) found that treating silage with formaldehyde at 1.7% (w/w) of DM reduced apparent digestibility of N by 10%. Rumen NH_3 concentration and molar proportions of iso- and n-valeric acids were reduced

by the treatment, suggesting a reduction in protein breakdown and rumen fermentation processes. Koenig et al (1978) fed formaldehyde treated (1%, w/w) caged layer waste at 10% of the diet on a DM basis, equivalent to 31% on as fed basis to lambs and steers. After an adaptation period to the waste the lambs were consuming as much DM as the control group, and their feed efficiency was not significantly different. In the steers they observed less feed intake and lower gains but equal feed efficiency, compared to the controls.

The treatment of caged layer waste with 2% (w/w) paraformaldehyde by Flipot et al (1975) resulted in a reduction of the apparent digestibilities of DM and energy, when compared to a diet containing 3% (w/w) tannic acid treated waste, possibly a result of over protection of protein.

Metabolism and Performance of Ruminants Fed Poultry Waste

Nitrogen Utilization. Apparent digestibility of crude protein of diets containing poultry litter was inversely related to the amount of waste included in the diet (Bhattacharya and Fontenot, 1965; Tagari et al, 1976; Bhattacharya and Fontenot, 1966). However the ensiling of poultry litter with corn forage resulted in an increase in apparent digestibility of crude protein as the level of

litter was increased in the silage (Harmon et al, 1975).

Bhattacharya and Fontenot (1965) reported no differences on N retention when poultry litter supplied 25 or 50% of the dietary N. Similar results were obtained by Tinnimit et al (1972) when dried poultry waste provided 40 to 49% of the dietary N. Gihad (1976) utilized dehydrated caged layer waste as a protein supplement for high roughage tropical hay. Incorporation of layer waste at a level of 33.3% of the daily rations resulted in an increase in voluntary intake; dry matter, crude protein, crude fiber, ether extract and energy digestibilities; and N retention, therefore, providing an economic covering of the protein shortage in the tropics.

Weight Gains. Supplementation of corn silage with wet hen excreta resulted in similar weight gains in cattle as using urea as a protein supplement, but lower gains, compared to those supplemented with soybean meal (Smith et al, 1978). Poultry waste supplementation has produced daily gains at least 90 to 92% of those observed with soybean meal (Smith et al, 1972) or cottonseed meal (Noland et al, 1955). However there was a tendency for a decrease in weight gains as the supplementation of waste increased (Cullison et al, 1976). Also, an increase in the feed requirement per megacalorie of gain was obtained.

Meat Evaluation. Broiler excreta was used as a protein supplement for steers fed finishing diets during 142 d with no difference in dressing percent, marbling score or carcass grade when the excreta provided 0, 50 or 100% of the supplemental protein (Cullison et al, 1976). Beef roasts from steers receiving 100% supplemental protein from broiler manure/wood shavings, broiler manure/peanut hulls, dried hen manure were found to be as acceptable as the ones from steers receiving supplemental soybean protein. No difference on dressing percentage, marbling score or carcass grade was found between treatments (Cullison et al, 1976).

El Sabban et al (1970) reported that a taste panel found no differences in the roasts of beef from cattle that consumed autoclaved or dried caged layer waste compared to those fed soybean meal or urea as a protein supplement.

Health Aspects of Feeding Poultry Waste

Angus et al (1978) conducted a study feeding 15, 30, 45 or 60% dried poultry waste from either battery or broiler units to weanling lambs for 16 wk. Animals consuming 60% broiler waste had increases in Ca and P of the kidney cortex. A two-fold increase in kidney Ca was observed when battery waste was increased from 15 to 60%. The use of 45 or 60% battery waste resulted in the fall of plasma albumin. Hemoglobin and hematocrit decreased as the levels of battery waste increased; these effects were not observed in the

broiler waste fed group. The levels of liver Cu for broiler and battery waste were lower than those associated with Cu poisoning. The inclusion of high levels of dried battery waste (45 and 60%) in the barley diet caused anorexia, hypoalbuminemia, ascites, centrilobular necrosis and fibrosis in the liver after 8 wk, whereas the same levels of broiler waste did not produce these abnormalities. After 16 wk severe damage to renal tubular epithelial cells was observed, suggesting a lower resistance to kidney infection. Later, Suttle et al (1981) looked for the nature of the toxic substances in dried poultry battery waste. They suggested that a nitrosamine might be the toxic principle in artificially dried waste. No nitrosamines were detected on the naturally dried waste. Their conclusion was that the variability in hepatotoxicity of battery waste fed animals may be related to the extent to which storage or drying conditions favor the formation of nitrosamines or their precursors. Fontenot et al (1972) reported Cu toxicity in ewes fed broiler litter containing 57.1 and 109.1 ppm of Cu.

Drug residues and their effect on growth of lambs fed waste containing Ampro-plus and 3-nitro hydroxyphenil arsenic acid were studied by Brugman et al (1968). It appeared that Ampro-plus and 3-nitro impaired growth in smaller lambs but not in larger lambs. Ampro-plus was used to study VFA concentrations in-vitro. An increase of 10

times of this compound produced an increase in butyric acid but a significant decrease in propionic acid. The rate of production of acetic, valeric and isovaleric remained constant. Chemical analyses of heart, spleen, 12th rib, kidney, kidney fat, liver and brain of the lambs did not reveal residues of Ampro-plus, although these drugs were found on the fed waste.

Carniere et al (1968) reported that cattle fed poultry litter may react as false positive to the test for tuberculosis due to a reaction to *Mycobacterium avium* if present in the waste.

Chapter III

JOURNAL ARTICLE I

PRESERVATION OF FRESH CAGED LAYER WASTE WITH DIFFERENT ADDITIVES

ABSTRACT

Fresh caged layer waste (2d) was collected from a commercial egg laying house and treated with the following: 1) none, 2) 2% formaldehyde, 3) 3% sodium metabisulfite, 4) 3% formic and 2% propionic acids, and 5) 1% formaldehyde and 2% propionic acid (w/w), on a wet basis. The mixtures were stored in polyethylene lined 208 liter metal drums for 42 d. An upside-down polyethylene bag was placed on the top of each drum but air escape valves were kept open to achieve an aerobic system, and to make possible the measurement of NH_3 and H_2S gases. Control and sodium metabisulfite treatments showed maggot infestation, strong NH_3 odor, microbial proliferation and color changes which resembled putrefaction. Formic/propionic and formaldehyde/propionic treatments showed mild signs of initial decomposition at the 28 to 35 d, when NH_3 gas started to be detected and total coliforms began to repopulate. Formaldehyde-treated waste showed no signs of decomposition throughout the 42 d preservation period.

(Key words: Caged Layer Waste, Chemical Agents, Preservation, Putrefaction)

INTRODUCTION

Animal waste can be utilized as a source of nutrients for plants or animals, or as a substrate for microbial and insect protein synthesis or methane production by microorganisms (Fontenot, 1979). Caged layer waste constitutes a potential source of nutrients due to its crude protein, energy and mineral content. Recycling through ruminants becomes especially attractive due to their ability to utilize NPN (Oltjen, et al, 1968) which constitutes up to two-thirds of the N content of poultry waste.

Storing fresh caged layer waste without preservation results in deterioration of the material and loss of nutrients (Flegal et al, 1972) due to microbial action (Schefferle, 1965). Chemical agents such as formaldehyde or organic acids have been widely used to preserve high moisture organic material (Lindhahl, 1974; Narasimhalu, 1981; Singh-Verna, 1974; Smith et al, 1978).

The present study was conducted to investigate the potential of various chemicals on the preservation of fresh caged layer waste.

EXPERIMENTAL PROCEDURE

Preservation

Fresh caged layer waste (2 d old) was obtained from a

commercial farm¹ in which the hens were fed a 14% (w/w) crude protein commercial diet². The waste was transported by a conveyor belt to the bed of a truck which was lined with polyethylene sheets. After arrival to Blacksburg the waste was sampled and DM content was rapidly determined in a microwave oven.

The waste was placed in 208 liter metal drums lined with .8 mm polyethylene bags, and mixed using a small auger with the following chemicals: no additive, 2% formaldehyde, 3% sodium metabisulfite, 3 formic and 2% propionic acids, and 1% formaldehyde and 2% propionic acid. Water was added in order to equalize the DM content of the final mixtures among treatments. The composition of the material placed in the drums according to the treatments is presented in table 1. Sampling was done using a grain sampler³ in order to obtain a representative sample from the different levels across the drum.

Samples for microbial analysis were first taken 2 h after the mixing period, placed in 100 ml sterile jars and

¹Greenvalley Farms, Damascus, VA

²Purina Accu-Lay 120

³A 1.75 m x 5 cm Polyvinyl Chloride (P.V.C.) pipe fitted into a 1.5 m x 5.5 cm P.V.C. pipe, both pipes had a 2.5 cm slot from bottom to top, matching of slots from both pipes allowed obtaining samples from different levels across the drum.

Table 1. COMPOSITION OF TREATED CAGED LAYER WASTE ACCORDING TO TREATMENTS^a

Control	Treatments				
	Formaldehydeb	Sodium metabisulfitec	Formic/propionic acid / acide	Formaldehydeb / propionic acide	
Waste	94.6	93.6	92.17	93.6	
Chemical	5.4	3.04	3.41 / 2.0	2.7 / 2.0	
Water	3.4	3.36	2.42	1.7	

^a Three drums of waste for each treatment

^b Formaldehyde 37%

^c Sodium metabisulfite 98.7%

^d Formic acid 88%, liter = 1.25 kg.

^e Propionic acid 100%

sealed. Microbial analyses were done within 24 h of sampling time. The other samples were placed in 200 ml jars and frozen for chemical analysis. After the initial sampling the drums were covered with an .8 mm polyethylene bag which was provided with an air escape valve in order to obtain an aerobic system. The cover bag was developed to measure NH_3 and H_2S content of the gases being emanated. The first gas sampling was done 9 h after mixing. The mixtures were left in the barrels for 42 d and sampling was done on days 0, 7, 14, 21, 28, 35 and 42.

Chemical Analysis

Ammonia and H_2S were measured in air collected from the drums with a gas analyzer⁴. Nitrogen components were determined on wet samples of the waste by the following methods: total N (AOAC, 1980); protein N by precipitation with tungstic acid followed by N determination (AOAC, 1980); uric acid N (Buys and Potgieter, 1959).

A quantitative test for total coliforms was done following the standard method for testing pasteurized milk (Anonymous, 1967). Fecal coliform counts were determined by the membrane filtrate technique (Millipore, 1973). Counts were done with a Quebec Colony Counter. Dry matter

⁴Gastec, Sensidyne pump.

was determined by drying in a forced-draft oven at a maximum of 60 C for 24 h.

Statistical Analyses

The data were treated by analysis of variance by the general linear model procedure of SAS (1982). Differences between treatments over time were tested by Tukey's pairwise comparisons. Differences within treatments over time were tested by orthogonal polynomials for linear, quadratic and cubic trends.

RESULTS AND DISCUSSION

Initial DM content of the sodium metabisulfite treated waste was higher ($P < .05$) than for the other treatments (table 2). This effect may be attributed to the fact that sodium metabisulfite is a powder, while the other chemicals were in liquid form, and volatilized during DM determination. Final DM content of the control waste was lower ($P < .05$) than for the other treatments. A linear decrease ($P < .05$) with time was observed in DM of the control and sodium metabisulfite treated waste. The formic/propionic treatment showed a linear increase ($P < .05$) in DM during the storage period.

Table 2. DRY MATTER CONTENT OF CAGED LAYER WASTE OVER TIME

Days	Treatment				SEb	
	None ^a (Control)	Formaldehyde	Sodium metabisulfitea	Formic/ propionica		Formaldehyde/ propionica
0	30.02c	30.02c	32.43d	30.11c	31.75c	.29
7	29.56c	29.54c	32.75d	30.96cd	32.13d	.36
14	29.24c	29.61ce	32.56d	31.17cde	31.92d	.38
21	28.85c	29.80ce	32.25d	31.19de	32.00d	.36
28	28.79e	30.53de	31.97d	31.54d	32.29d	.35
35	28.77e	30.39de	31.01d	31.04d	31.82d	.32
42	28.12c	30.66d	30.67d	31.61d	31.54d	.38
SEb	.16	.19	.21	.12	.09	

^a Linear effect of time ($P < .05$)

^b Standard error of means

^{c,d,e} Means on the same day not having a common superscript are different ($P < .05$)

Total N of control waste showed a linear ($P < .05$) increase with time throughout the storage period (table 3). This effect does not agree with the observed loss of N during storage of untreated poultry waste by Flegal et al (1972). The possible explanation for this effect is the reduction of nitrates to NH_3 by aerobic bacteria. This NH_3 can be assimilated by the bacteria as a source of N for biosynthesis of amino acids. The development of enzymes necessary for assimilation of nitrate N may occur during anaerobic or aerobic growth of many bacteria (Payne, 1973). Nitrates do not constitute part of the total N content that is determined by the Kjeldahl procedure (AOAC, 1980). Another possible factor contributing to an increase in the total N was the presence of fly (*Musca domestica*) eggs and maggots, which proliferated in the control.

Initial protein nitrogen was similar ($P > .05$) among treatments (table 4). The control waste showed a decrease, then an increase with time (quadratic trend, $P < .05$), while the formaldehyde treatment showed an increase, then a decrease (quadratic trend, $P < .05$) during the storage period. Sodium metabisulfite showed a linear ($P < .05$) decrease in protein N.

Initial NPN was similar among treatments (table 5). The control waste showed an increase, then a decrease with

Table 3. TOTAL NITROGEN CONTENTS OF CAGED LAYER WASTE OVER TIME

Days	Treatment				SEC	
	None ^b (Control)	Formaldehyde	Sodium metabisulfite	Formic/ propionic		Formaldehyde/ propionic
0	5.06d	4.95de	4.62e	5.08d	4.87de	.05
7	5.36d	5.13e	4.65de	5.00de	4.80e	.07
14	5.52d	4.98e	4.64e	4.82e	4.74e	.09
21	5.26d	4.94d	4.88d	4.79e	4.73e	.05
28	5.58d	5.00e	4.88e	4.81e	4.69e	.09
35	5.50d	4.87e	4.86e	4.95e	4.81e	.07
42	5.44d	4.97e	4.87e	4.76e	5.06de	.07
SEC	.04	.03	.04	.03	.03	

a Dry basis

b Linear effect of time ($P < .05$)

c Standard error of means

d,e Means on the same day not having a common superscript are different ($P < .05$)

Table 4. PROTEIN NITROGEN CONTENTS OF CAGED LAYER WASTE OVER TIME

Days	Treatment				SED	
	None b (Control)	Formaldehyde ^b	Sodium ^c metabiasulfite	Formic/ propionic		Formaldehyde/ propionic
0	1.76e	1.85e	1.76e	1.78e	1.91e	.02
7	1.69e	2.01f	1.71e	1.88ef	1.91ef	.04
14	1.59e	2.04f	1.69g	1.92fg	1.89fg	.05
21	1.66e	1.96f	1.64e	1.83ef	1.82ef	.04
28	1.47e	1.63ef	1.31e	1.71f	1.82ef	.05
35	1.47ef	1.62f	1.30e	1.78f	1.85f	.06
42	1.85e	1.64ef	1.47f	1.71ef	1.80e	.04
SED	.03	.04	.04	.02	.01	

a Dry basis

b Quadratic effect of time (P<.05)

c Linear effect of time (P<.05)

d Standard error

e,f,g Means on the same day not having a common superscript are different (P<.05)

Table 5. NON PROTEIN NITROGEN CONTENTS OVER TIME

Days	Treatment				SED	
	None ^b (Control)	Formaldehyde	Sodium ^c metabisulfite	Formic/ propionic		Formaldehyde/ propionic
0	3.30e	3.10e	2.86e	3.30e	2.95e	.06
7	3.67e	3.11f	2.93f	3.11f	2.88f	.08
14	3.92e	2.93f	2.94f	2.89f	2.85bf	.11
21	3.59e	2.97f	3.23ef	2.96f	2.90f	.07
28	4.10e	3.36fg	3.57f	3.09g	2.87g	.12
35	4.02e	3.24fg	3.55f	3.17fg	2.95g	.10
42	3.63e	3.32ef	3.39ef	3.04f	3.26ef	.06
SED	.06	.04	.07	.04	.04	

a Dry basis

b Quadratic effect of time (P<.05)

c Linear effect of time (P<.05)

e, f, g Means on the same day not having a common superscript are different (P<.05)

time (quadratic $P < .05$), formaldehyde and sodium metabisulfite showed a linear increase ($P < .05$) with time. At the end of storage formic/propionic treated waste tended to be lower in NPN than the other wastes.

Initial uric-acid N tended to be lower for the sodium metabisulfite and formaldehyde/propionic treated wastes (table 6). All treatments showed a linear decrease ($P < .05$) throughout the storage period. Formaldehyde and formaldehyde/propionic had the highest uric acid N among treatments by d 42. Storage of untreated caged layer waste has resulted on losses of uric acid N (Evans et al, 1978) and total N (Flegal et al, 1972). Uric acid is first oxidated and hydrolyzed to urea with subsequent hydrolysis to NH_3 as the result of microbial action (Schefferle, 1965). In the present study although no total N losses were observed on treated or untreated waste, uric acid N decreased through the storage period on all the treatments. After 42 d formaldehyde and formaldehyde/propionic treated waste had lost less uric acid N than the other wastes followed by formic/propionic.

Ammonia gas was detected after the first week on the control and sodium metabisulfite treatments, reaching its highest value on d 28 and 35, respectively (table 7). Formaldehyde/propionic showed medium levels of NH_3 at the

fourth week while formic/propionic showed low levels at that time. Hydrogen sulfide gas was not detected on any of the wastes.

Total coliforms were similar ($P > .05$) among treatments at the initial sampling (table 8). Formaldehyde was effective in eliminating total coliforms throughout the storage period. Formic/propionic and formaldehyde/propionic were effective in controlling the coliform population until d 35. Total coliforms kept growing during the storage period on the control and sodium metabisulfite treatments.

Fecal coliforms were similar ($P < .05$) among treatments at initial sampling (table 9). Formaldehyde, formic/propionic and formaldehyde/propionic were effective on eliminating them, but the organisms continued multiplying on the control and sodium metabisulfite treatments.

Table 6. URIC ACID NITROGEN CONTENTS OF CAGED LAYER WASTE OVER TIME

Days	Treatment				SEC	
	None b (Control)	Formaldehydeb	Sodium b metabisulfite	Formic/ b propionic		Formaldehyde/b propionic
0	1.64d	1.51de	1.44e	1.50de	1.46e	.02
7	1.58d	1.53d	1.33e	1.53e	1.44de	.02
14	1.47d	1.48d	1.22e	1.42d	1.39d	.02
21	1.32de	1.41d	1.23e	1.35de	1.36d	.02
28	1.32d	1.41d	1.12e	1.31d	1.24de	.03
35	1.24d	1.30d	1.09e	1.33d	1.23de	.02
42	1.16d	1.33f	1.12d	1.20d	1.25d	.02
SEC	.04	.02	.03	.02	.02	

a Dry basis
b Linear effect of time (P<.05)
c Standard error of means
d,e,f Means on same day not having a common superscript are different (P<.05)

Table 7. AMMONIA GASA FROM CAGED LAYER WASTE OVER TIME

Days	Treatment				SEC
	None (Control)	Formaldehyde	Sodium metabisulfite	Formic/ propionic	
0	5d	0d	0d	0d	.53
7	376d	0e	100f	0e	39.84
14	466d	0e	360d	0e	55.53
21	633d	0e	266f	1.6d	66.98
28	866d	0e	366f	67.3e	86.27
35	500d	0e	466d	1.6e	63.75
42	600d	0e	366f	2e	61.41
SEC	56	0	38	9	25

a ppm
b Linear effect of time (P<.05)
c Standard error of means
d,e,f Means on the same day not having a common superscript are not different (P<.05)

Table 8. TOTAL COLIFORMS IN CAGED LAYER WASTE OVER TIME

Days	Treatment						SED
	None (Control)	Formaldehyde b	Sodium metabisulfite	Formic/ c propionic	Formaldehyde/c propionic		
	colonies/g						
0	444x103 e	339x103 e	395x103 e	381x103 e	362x103 e	13x103	
7	169x103 e	0 e	38x103 e	0 e	0 e	18x103	
14	826x103 e	0 e	330x104 f	0 e	0 e	34x104	
21	466x103 e	0 e	313x103 e	0 e	0 e	53x103	
28	252x105 e	0 f	280x103 f	0 f	0 f	27x105	
35	219x105 e	0 f	242x104 g	3x102 e	23x103 e	23x105	
42	264x105 e	0 f	221x105 e	3x102 f	27x103 f	32x105	
SED	268x104	26x103	166x104	29x103	27x103		

a Dry basis
b Linear effect of time (P<.05)
c Quadratic effect of time (P<.05)
d Standard error of means
e,f,g Means on the same day not having a common superscript are different (P<.05)

Table 9. FECAL COLIFORMS IN CAGED LAYER WASTE OVER TIME

Days	Treatment					SEC
	None (Control)	Formaldehyde ^b	Sodium metabisulfite ^b	Formic/propionic ^b	Formaldehyde/propionic ^b	
0	24x10 ¹ d	24x10 ¹ d	24x10 ¹ d	25x10 ¹ d	25x10 ¹ d	5
7	16x10 ¹ d	0 d	30x10 ¹ d	0 d	0 d	30
14	19x10 ³ d	0 d	36x10 ¹ d	0 d	0 d	2x10 ³
21	15x10 ² d	0 d	35x10 ¹ d	0 d	0 d	1x10 ²
28	31x10 ² d	0 d	36x10 ¹ d	0 d	0 d	3x10 ²
35	364x10 ³ e	0 d	24x10 ² d	0 d	0 d	57x10 ³
42	123x10 ³ d	0 d	22x10 ² d	0 d	0 d	13x10 ³
SE	40x10 ³	18	26x10 ²	20	20	

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a Dry basis
b Linear effect of time (P<.05)
c Standard error of means
d,e Means on the same day not having a common superscript are different (P<.05)

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Chapter IV
JOURNAL ARTICLE II

NUTRITIONAL VALUE OF FRESH CAGED LAYER WASTE
TREATED WITH DIFFERENT CHEMICALS

ABSTRACT

Fresh caged layer waste was used for a metabolism trial with 30 wethers with average weight of 32 kg. Diets fed were: 1) low protein basal (58% roughage and 42% concentrates) alone, or supplemented with caged layer waste treated with 2) 2% formaldehyde, 3) 1% formaldehyde and 2% propionic acid 4) 3% formic and 2% propionic acids (wet basis) stored for a minimum of 42 d prior to feeding and 5) soybean meal. The treated wastes and soybean meal provided approximately 50% of the total dietary N. Dry matter digestibility was not affected by N supplementation. Apparent digestibility of crude protein was higher ($P < .05$) for the soybean meal supplemented diet. No difference was observed in crude protein digestibility among the treated waste diets. Nitrogen absorption was higher for the sheep fed formaldehyde/propionic treated waste than for those fed the other treated waste diets. Nitrogen retention was higher for lambs fed the soybean meal supplemented diet. Lambs fed the formaldehyde/propionic treated waste diet had

higher N retention than those fed the other treated waste diets.

(Key words: Caged Layer Waste, Chemical Preservation, Nitrogen Retention, Digestibility, Sheep)

INTRODUCTION

Caged layer waste has an average crude protein content of 30%, dry basis. Non-protein nitrogen (NPN) comprises 50 to 60% of the total N, (Bhattacharya and Taylor, 1975) in which uric acid contributes the main portion (Evans et al, 1978). Ruminants possess the ability to utilize NPN. Uric acid was found to be efficiently utilized by rumen microflora (Belasco, 1954). Therefore, the recycling of caged layer waste through incorporation in ruminant diets offers an alternative as an inexpensive source of N.

Feeding dehydrated caged layer waste to ruminants has given satisfactory results (Bhattacharya and Taylor, 1975) Dry heating broiler litter as a preservation procedure resulted in significant losses of crude protein (Fontenot et al, 1971). Nitrogen utilization was similar for sheep fed, autoclaved, dry heated or chemically treated (paraformaldehyde) broiler litter (Caswell et al 1975).

The present study was conducted to evaluate N utilization of chemically treated fresh caged layer waste, when incorporated in sheep diets.

EXPERIMENTAL PROCEDURE

A metabolism trial was conducted with 30 crossbred wethers to study the N utilization of the diets containing the preserved waste. The utilization of other nutrients was studied also. The sheep, which had an initial weight of 32 kg were assigned to six blocks of five animals each based on the weight and origin. The sheep within each block were randomly allotted to the following diets: 1) Basal alone, or supplemented with caged layer waste treated with 2) 2% formaldehyde, 3) 1% formaldehyde and 2% propionic acid, 4) 3% formic and 2% propionic acids or 5) soybean meal. The composition of the experimental diets is presented in table 10. The waste and soybean meal in the experimental diets provided approximately 50% of the total N of the diet. Sensible changes in color and smell that resembled putrefaction conditions were easily detected in the control and sodium metabisulfite treatments during storage period (Chapter III). These changes, plus the proliferation of maggots and high microbial population lead to the decision of not utilizing the waste from these treatments in this experiment.

All animals were treated for internal parasites and received 500,000 I.U. of vitamin A and 75,000 I.U. of vitamin D IM. The sheep were kept in metabolism stalls similar to

those described by Briggs and Gallup (1949), which allowed separate collection of feces and urine. The animals were fed 650 g DM daily in two equal feedings at 12 h intervals and water was provided ad libitum except during the 2-h feeding periods. The components of the diets were mixed by hand prior to each feeding to achieve a homogenous mix. The animals were allowed a 5-d adaptation period to the stalls and a 10-d transition period in which the waste was gradually incorporated to the diet. Test diets were fed for a 10-d preliminary period followed by a 7-day total collection period. Refusals and samples of the diets were obtained and frozen 2 d prior to the beginning and 2 d prior to the end of the collection period. Refusals from each feeding period were collected separately by animals and later composited for analysis. During the collection period feces were collected once daily, dried for 24 h in a forced-draft oven at a maximum of 60 C, and composited by animal in metal containers with loosely fitted lids. At the end of the trial the composited feces were allowed to air equilibrate, weighed, ground and sampled for analysis.

Urine was collected daily in plastic containers with a mixture of 15 ml of 1:1 (v/v) mixture of concentrated H₂SO₄ and H₂O. Daily urine collections were diluted to a constant weight by addition of water, checked for acidity and a 2%

sample by volume was obtained and kept in closed refrigerated containers. Urine sub-samples were analyzed for total N (AOAC, 1980) at the end of the trial.

At the end of the collection period ruminal samples were taken by stomach tube 2 h after the last feeding. The ruminal ingesta was filtered through four layers of cheesecloth. The filtered fluid was used for determinations of pH (electrometrically), ammonia-N (Beecher and Whitten, 1970) and volatile fatty acids. (Erwin et al, 1961, with a Vista 6000 gas chromatograph)

Blood samples were taken 6 h after the last feeding by jugular puncture and analyzed for blood urea-N by the colorimetric procedure (Coulombe and Favreau, 1963). Analysis of the diet components and feces for crude protein, ether extract and ash were by the AOAC (1980) procedures. Dry matter was determined by drying in a forced-draft oven at a maximum of 60 C for 24 h.

Statistical Analyses

The data were treated by analysis of variance using the general linear model procedure of SAS (1982). The following orthogonal contrasts were made: 1) basal diet vs nitrogen supplemented diets 2) soybean vs waste diets 3) formaldehyde vs formaldehyde/propionic and formic/propionic and 4) formaldehyde/propionic vs formic/propionic.

RESULTS AND DISCUSSION

Chemical Composition of the Diets. The DM content varied from 67 to 91%, the caged layer waste being responsible for the low DM of the diets in which it was included (table 10).

The diet with the formic/propionic treated waste had the lowest crude protein content (table 10) due to the lower crude protein content of the formic/propionic treated waste compared to the other treated wastes (table 11).

Apparent Digestibility. Dry and organic matter apparent digestibilities were similar ($P > .05$) for all the diets (table 12). Apparent digestibility of crude protein was improved by protein supplementation as a result of the increase in N intake. The soybean supplemented diet had the higher ($P < .05$) apparent digestibilities of crude protein and ether extract compared to the waste diets. Apparent digestibility of crude protein tended to be lower for the formaldehyde treated waste compared to the other waste diets. Apparent digestibility of crude protein was lowest ($P < .05$) for the basal diet and was improved by protein supplementation. The soybean supplemented diet had the higher ($P < .05$) of apparent digestibilities of crude protein and ether extract, compared to the waste diets.

Table 10. COMPOSITION OF DIETS FED IN THE METABOLISM TRIAL

Item	Basal diet	Nitrogen supplements			
		Formaldehyde	Formaldehyde/ propionic acid	Formic/ propionic	Soybean meal
Ingredient composition, %					
Corn cobs, residuea	10	17.3	17.3	17.3	40
Corn, dent yellow, grain, grnd.	35	27.9	27.9	27.9	18.9
Sugarcane, molasses, dehy	5	5	5	5	5
Wheat straw, grnd.	48	31.3	31.3	31.3	21.8
Soybean, seeds, mech-extd grnd.	--	--	--	--	12.5
mx 7% fiber	--	--	--	--	--
Caged layer waste	--	18	18	18	--
Defluorinated phosphate, grnd.	1.5	--	--	--	1.3
Salt	0.5	0.5	0.5	0.5	0.5
Chemical composition					
Dry matter %	91.62 ^a	68.16	69.08	67.77	91.47
Composition of dry matter, %					
Crude protein	5.89	10.67	11.09	10.10	10.52
Ether extract	2.45	2.44	2.39	2.41	1.92
Ash	2.24	6.13	6.27	5.98	2.25

a Lite-R-Cobs, pellets; The Andersons, Maumee, Ohio

Table 11. CHEMICAL COMPOSITION OF TREATED CAGED LAYER WASTE

Item	Treatment		
	Formaldehyde	Formaldehyde/ propionic	Formic/ propionic
Dry matter %	33.25	35.54	32.28
Composition of dry matter, %			
Crude protein	32.04	32.10	29.78
Ether extract	1.75	1.68	1.73
Ash	22.5	21.09	23.86

Table 12. APPARENT DIGESTIBILITY BY SHEEP

Item	Basal diet	Nitrogen supplements				SEA
		Caged layer waste treatment Formaldehyde/propionic	Formaldehyde/propionic	Formic/propionic	Soybean meal	
Dry matter	61.42	58.63	60.25	60.40	61.63	1.36
Organic matter	63.54	60.06	61.88	61.92	63.16	1.23
Crude protein b,c	42.65	55.85	59.92	59.15	65.05	1.98
Ether extract b,c	71.76	61.88	61.08	61.18	69.21	0.53

a Standard error of means

b Basal diet vs nitrogen supplemented diets differ (P<.05)

c Soybean vs waste diets differ (P<.05)

Apparent digestibility of crude protein tended to be lower for the formaldehyde treated waste diet, compared to the other waste diets.

Nitrogen Utilization. Nitrogen intake was lowest for the sheep fed the basal diet with small differences among the supplemented diets (table 13).

Fecal N excretion was lowest ($P < .05$) for the basal diet. Among sheep fed the supplemented diets fecal N excretion was lower ($P < .05$) for lambs fed the soybean meal diet. No differences were recorded among the sheep fed the waste diets.

Urinary N was lower ($P < .05$) for the animals consuming the basal diet. When compared to sheep fed the treated waste diets, sheep fed soybean meal had lower urinary N excretion.

Nitrogen absorption, expressed as grams per day, was lowest ($P < .05$) for sheep fed the basal diet. Sheep fed soybean meal absorbed more N ($P < .05$) than those fed waste. No differences were recorded among sheep fed the waste diets.

Nitrogen retention was lowest for lamb fed the basal diet ($P < .05$) and highest ($P < .05$) for those fed the soybean diet. No differences were observed among sheep fed the waste diets.

Table 13. NITROGEN UTILIZATION BY SHEEP FED A BASAL DIET ALONE OR SUPPLEMENTED

Component	Basal diet	Nitrogen supplements				Soybean meal	SEA
		Caged layer waste treatments Formaldehyde	Formaldehyde/ propionic	Formic/ propionic	Soybean meal		
Nitrogen intake g/d b,d	6.56	12.02	12.55	11.47	11.95	0.07	
Nitrogen excretion g/d							
Fecal b,c	3.77	5.30	5.03	4.68	4.17	0.20	
Urinary b	2.84	4.93	5.34	4.93	4.17	0.50	
Total	6.61	10.23	10.37	9.61	8.34		
Nitrogen absorbed							
Grams per day b,c	2.78	6.72	7.52	6.78	7.77	0.20	
Percent of intake	42.37	55.90	59.92	59.11	65.00		
Nitrogen retention							
Grams per day b,c	-0.05	1.79	2.18	1.86	3.61	0.50	
Percent of intake b,c	3.01	14.72	17.39	16.16	30.09	4.34	
Percent of absorbed b,c	8.36	25.63	28.84	27.27	46.77	7.66	

a Standard error of means

b Basal diet vs nitrogen supplemented diets differ (P<.05)

c Soybean meal diet vs waste diets differ (P<.05)

d Formaldehyde/propionic vs Formic/propionic differ (P<.05)

From the above data we can conclude that supplementation of a basal diet with chemically treated caged layer waste improves the nutritional value of the diet. Although the improvement may not be as great as that observed when supplementing with soybean meal, it resulted in a positive N retention which means that caged layer waste is efficiently used by sheep at the levels fed. These same effects were observed by El-Sabban et al (1970) when utilizing autoclaved or dried poultry litter as protein supplements.

Ruminal Fluid and Blood Parameters

Ruminal fluid pH was similar ($P > .05$) for sheep fed the basal and N-supplemented diets (table 14). Ruminal fluid $\text{NH}_3\text{-N}$ was lowest for sheep fed the basal diet. The value was higher ($P < .05$) for sheep fed the treated-waste diets than for those fed the soybean meal diet. This difference was expected since the waste contains a high percent of NPN which is readily converted to ammonia by the rumen microflora, whereas in soybean meal up to 80% of its crude protein content is true protein and this protein is low in solubility and degradation rate due to the heat applied on the manufacturing process of the meal which results in rumen escape of intact undegraded protein (Van Soest, 1982).

Blood urea was lowest for sheep fed the basal diet, with no significant differences among the sheep fed the

supplemented diets (table 14).

Total ruminal VFA was lower ($P < .05$) for the lambs fed the formaldehyde-treated waste than for those fed treated waste diets (table 15). A similar effect was observed for proportions of propionic and butyric acids. Feeding formaldehyde treated lucerne hay to sheep resulted in low VFA concentration in the rumen fluid (Barry, 1976). Formaldehyde forms a highly resistance complex with glucose, making it unavailable for degradation in the rumen and abomasum (Covey and Coppock, 1977).

Table 14. RUMINAL FLUID PH AND AMMONIA NITROGEN AND BLOOD UREA OF SHEEP

Item	Basal diet	Nitrogen supplements			SEA
		Formaldehyde	Caged layer waste treatment Formaldehyde/ propionic	Formic/ propionic soybean meal	
Ruminal fluid pH	6.40	6.73	6.54	6.63	6.40
Ruminal fluid b,c NH ₃ -N, mg/100 ml	3.67	26.45	29.92	26.57	17.68
Blood urea, b mg/100 ml	6.12	14.55	19.21	19.03	13.69

a Standard Error of means.

b Basal diet vs nitrogen supplemented diets differ (P<.05)

c Soybean meal diet vs waste diets differ (P<.05)

Table 15. RUMINAL FLUID VOLATILE FATTY ACID CONCENTRATION OF SHEEP

	Basal diet	Nitrogen supplements			SEA
		Caged layer waste treatment Formaldehyde	Formaldehyde/ propionic	Formic/ propionic	
Total volatile fatty acids, ^b u moles/ml	66.59	62.21	74.63	77.51	4.89
Volatile fatty acids, moles/100 moles					
Acetic	47.57	43.57	48.52	49.98	3.28
Propionic ^b	14.07	12.25	16.40	16.83	1.01
Butyric ^b	6.62	4.73	7.55	8.51	0.73
Isobutyric ^c	0.51	0.64	0.65	0.67	0.04
Valeric ^c	0.45	0.62	0.53	0.51	0.04
Isovaleric ^c	0.73	0.85	0.94	0.96	0.06
				Soybean meal	
				75.56	

^a Standard error of means

^b Formaldehyde vs Formaldehyde/propionic and Formic/propionic differ ($P < 0.05$)

^c Basal diet vs nitrogen supplemented diet differ ($P < 0.05$)

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Chapter V

GENERAL DISCUSSION

The average crude protein content of the caged layer waste used in the present study was 30.83% which agrees with the values reported by Bhattacharya and Taylor (1975). Two-thirds of the total N content was in the form of NPN and uric acid comprised one-third of the NPN, which agrees with Evans et al (1978).

Storage of wet caged layer waste has resulted in substantial losses in N (Flegal et al, 1972) as a result of the decomposition of uric acid by microbial action (Schefferle, 1965). These N losses can be detected by the ammoniacal smell coming from the waste. In the present study no N loss was detected when total N was measured on untreated caged layer waste during a 42-d period. Possibly, reduction of nitrate to ammonia for amino acid biosynthesis by bacteria was taking place (Payne, 1973). Nitrate N is not included in total N content by the Kjeldahl procedure (AOAC, 1980). Ammonia gas was detected at levels as high as 866 ppm in the untreated waste. Uric acid content on the untreated waste was substantially lower after 42 d, indicating oxidation and hydrolysis to NH_3 by bacterial action (Schefferle, 1965).

Formaldehyde has been used as a bacterial growth retardant (Lindahl, 1974) and as a preservative for wet caged layer excreta intended for recycling by feeding to livestock (Smith et al, 1978). Formic and propionic acid had also been tested for their antimicrobial action against coliforms, clostridia and bacilli (Woolford, 1984a., Woolford, 1984b.). Sodium metabisulfite proved to be effective at lower levels (0.05%) in controlling microbial population in broiler litter but it was ineffective in caged layer waste in the present study.

In the present study successful preservation was achieved using high levels of formaldehyde and formic and propionic acids, showing that these chemical agents have a potential for preservation of wet caged layer waste. It might be possible to decrease the cost of these treatments by decreasing the levels of chemicals used which might result in shorter preservation periods. This is something that should be evaluated, considering prices of other protein supplements and the length of storage period needed by farmers. Smith et al (1978) successfully preserved caged layer waste using 1% of 20% acetic/80% propionic acids, 14% acetic/56% propionic acids/30% formaldehyde or formaldehyde alone.

Using high levels of formaldehyde may reduce energy

digestibility, protein solubility and digestibility due to cross linking with protein molecules (Smith et al, 1978).

A decrease on protein digestibility was observed on the formaldehyde treated waste. Possibly, this could be lowered by reducing the level used.

Incorporation of poultry waste into ruminants diets has been shown to decrease protein digestibility in direct relation to their level in the diet (Tagari et al, 1976). Acceptable daily gains have been achieved by substituting a certain percentage of poultry waste for soybean meal (Noland, et al, 1955; Smith and Calver, 1972; Cullison et al, 1976).

It should be possible to replace some of the traditional N supplements with waste to an extent where animal performance would not be depressed.

A caged layer operation with a population of 10,000 birds will produce an average of 1 metric ton of waste/d. Assuming 10% losses on handling and transportation 900 kg per d of caged layer waste with an average moisture content of 75% would be available. This amount will be enough to provide 170 steers with an average weight of 500 kg with 50% of their daily crude protein requirement (NRC, 1985) when fed at 15% (dry basis) of daily DM intake.

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PRESERVATION AND NUTRITIONAL VALUE OF CAGED
LAYER WASTE TREATED WITH DIFFERENT PRESERVATIVES

by

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Committee Chairman: J.P. Fontenot

Animal Science

(ABSTRACT)

Two experiments were conducted with caged layer waste. In the first experiment fresh waste was treated with: no additive, 2% formaldehyde, 3% sodium metabisulfite, 1% formaldehyde and 2% propionic acid, 3% formic and 2% propionic acids and stored in polyethylene lined 208 liter metal drums. In experiment II waste treated with 2% formaldehyde, 1% formaldehyde and 2% propionic, 3% formic and 2% propionic (w/w), stored for at least 42 d, used in a metabolism trial as N supplements to a basal diet fed to sheep.

The formaldehyde, formaldehyde/propionic and formic/propionic treatments eliminated the bacterial decomposition of the waste and no undesirable fermentation was observed on the stored material. Waste treated with no additive or sodium metabisulfite underwent putrefaction.

Nitrogen supplementation of a basal diet with treated caged layer wastes improved apparent digestibility of crude protein and N retention in sheep fed these diets.

Supplementation of a basal diet with chemically treated caged layer waste improves the nutritional value of the diet which suggests that caged layer waste is efficiently utilized as a N source by ruminants when used as a protein supplement.

(Key words: Caged Layer Waste, Chemical Preservation, Nitrogen Retention, Digestibility, Sheep)