Nutritive Evaluation of Poultry Waste and Sudex Grass Silage for Sheep

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ABSTRACT : Cage layer waste and sudex grass were ensiled in the proportions of 0:100, 30:70, 40:60 and 50:50 wet basis, respectively. The influence of ensiling cage layer waste on *Salmonellae, Shigella, Proteus,* and total number of colony forming units (CFU) was investigated. The nutritive value of the silages was evaluated in a digestion trial. The experiment was conducted with 24 wethers allotted to four silages. Initial samples of cage layer waste showed 0.11×10^6 CFU and *Salmonellae, Shigella* and *Proteus* were present. Ensiling was effective in complete elimination of all the pathogens. Dry matter, crude protein and ash contents were increased linearly ($p < .01$) with the increase of cage layer waste in the silages (358 $g.kg^{-1}$ to 484 $g.kg^{-1}$; 76.3 $g.kg^{-1}$ to 183.2 $g.kg^{-1}$ and 38.5 $g.kg^{-1}$ to 169.4 $g.kg^{-1}$; DM basis, respectively). Water soluble carbohydrate values for silages were 38.3, 22.5, 20.1 and 20.0 $g.kg^{-1}$ DM basis, respectively. Ensiling decreased the pH values for all the silages and the decrease was higher for sudex grass ensiled alone than grass ensiled with cage layer waste. Lactic acid concentration in silages increased linearly ($p < .01$) with the increase of cage layer waste. The apparent digestibilities of DM, OM and CP for the animals fed sudex grass silage alone were, 496.0, 516.1, 496.7 $g.kg^{-1}$ DM basis respectively. However, digestibilities of all the components were higher ($p < 0.01$) for the animals fed silages containing cage layer waste. Among waste containing diets, the digestibilities of all the components showed quadratic affect ($p < 0.01$), increased for silages containing 30 and 40% cage layer waste and decreased when the level of waste increased from 40 to 50%. The results indicated that cage layer waste can be used upto 40 % in ruminants diet as a source of N without any adverse effect on the health of animals. Ensiling appeared to be feasible and effective method for eliminating the pathogen present in cage layer waste.

(**Key Words** : Cage Layer Waste, Pathogens, Digestibility, Ensiling, Sheep)

INTRODUCTION

Feeding animal waste to livestock is not a new endeavor as the practice of following cattle with swine in feedlot was common in 1920 (Day et al., 1979). Coprophagy has been recognized as a normal physiological phenomenon in rabbits and rodents (Madsen, 1939; Mangold, 1950) and is natural in many wild and domestic species (Bjornhog and Sjoblom, 1977). Cage layer waste is best used by ruminants as a source of supplemental protein (Calvert and King, 1977; Smith and Lindahl, 1977; Fontenot, 1982; Arave et al., 1990; Lober et al., 1992; Nadeem et al., 1993). Amino acid N of cage layer waste ranges from 37 to 45% of total N (Liebholz, 1969). About 40 to 60% of total N in poultry excreta is present in the form of NPN (Smith et al., 1978). Uric acid, the major NPN source in poultry excreta is degraded to ammonia by rumen microbes at a much slower rate than urea (Oltjen et al., 1968).

Feeding of poultry waste includes several health hazards like; pathogens, residues of pesticide, drugs and heavy metals (McCaskey and Anthony, 1979; Fontenot, 1982; Lober et al., 1992). Although no serious problem have resulted from feeding cage layer waste (Arave et al., 1990), apprehension exists concerning pathogenic organisms that could be transmitted through the use of poultry waste as a feed ingredients (Kirk, 1967).

Ensiling animal excreta has been shown to destroy pathogens (Albert, 1977; McCaskey and Anthony, 1975; McCaskey et al., 1985; Magar, 1988; Flachowsky et al., 1990). Smith and Calvert (1976) reported satisfactory acceptance and performance by sheep, beef and dairy cows (Arave et al., 1990), when ensiled cage layer waste

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was fed to animals. The objective of our study was to investigate the effect of ensiling cage layer waste and sudex grass on safety and nutritive value of the silages.

MATERIALS AND METHODS

Cage layer waste was mixed and placed on polyethylene sheet on the floor. Samples were taken from various sites, composited and subsampled to represent the initial samples of cage layer waste. Sudex grass (sorghum × sudan grass) was harvested, chopped and mixed to obtain homogenous mixture. Samples of sudex grass were taken, composited and subsampled to represent the initial sudex grass samples. The cage layer waste and sudex grass were mixed in the ratios of 0:100, 30:70, 40:60 and 50:50, wet basis, respectively.

The sudex grass and waste for a particular batch of silage was allowed to mix for 30 min. After thorough mixing the samples were taken for each batch to represent the samples before ensiling. Silages were prepared in metal drum (210 liter capacity) lined with double layer of polyethylene. Samples of sudex grass, cage layer waste and initial mixtures were frozen for later analysis. For microbial analysis, samples were aseptically taken in .5 liter sterilized mason jars and all samples for microbial analysis were done within 24 h of sampling. Metal drums were stored in covered shed for 21 days at room temperature. After 21 d, each silo was opened, top 5 cm layer was discarded because of mold growth and samples for microbial and chemical analysis were taken from different locations of silo. After removing samples for biological, chemical and fermentation characteristics, the bags of silos were immediately resealed.

Digestibility trial

Twenty four wethers (Kajali breed of Pakistan) weighing 30-35 kg were assigned to four blocks of six animals in each block, based on body weight. Sheep within each block were randomly allotted to four diets: (1) cage layer waste: sudex grass silage (0:100); (2) 30:70: (3) 40:60 and 50:50 ratios. Diets were given at 20 g $DM.kg^{-1}$ body weight per day. Experimental diets were given for 35 d and faeces were collected during the last 10 d in canvas bags held by harnesses, as described by Fontenot and Hopkin (1965).

Samples of diets were obtained at each feeding 2 d prior to the beginning and 2 d prior to the end of the collection period. All diet samples were immediately frozen in double thickness plastic bags and composited at the end of the trial. Faeces were collected each morning and dried in a forced draft oven at a maximum of 60℃ for a minimum of 24 h. At the end of trial, fecal composites were weighed, mixed and subsampled.

Biological and chemical analyses

Total number of colony forming units (CFU) were measured by a plate method (Millipore, 1973) and *Salmonella, Shigella* and *Proteus* were determined (Anonymous, 1967). The aseptic extracts were prepared by homogenizing 25 g samples with 225 ml of sterilized, distilled water in a blender at full speed for 1 min. The filtrates were collected in sterilized jars and were plated on specific medium for specific organisms. The nutrient agar containing NaCl was used for *Proteus,* Nutrient agar medium containing 0.4% selenite for *Shigella* and Wilson & Blair's bismuth sulfite medium for *Salmonella.* After Plating the mediums were incubated at 37℃ for 8 hours.

Samples of cage layer waste, sudex grass, initial mixtures, silages, feed and faeces were analyzed for N, (AOAC, 1988). Nitrogen was determined on wet samples. Dry matter of all the samples was determined by drying, in duplicate, 200 g samples material in forced draft oven at 60℃ until a constant weight was reached. Following equilibration with atmospheric air, the duplicate dried samples were weighed, composited and ground to pass 1 mm sieve and analyzed for NDF (Van Soest and Wine, 1967), ADF (Van Soest, 1963), lignin and cellulose (Van Soest and Wine, 1968).

Water extracts of cage layer waste, sudex grass, initial mixtures and silages were prepared by homogenizing 25 g wet material with 100 ml distilled water in a blender for 2 min. The homogenate was filtered through four layers of cheese cloth and filtrate was used for determining pH (electrometrically), lactic acid (Baker and Summerson, 1941) as modified by Pennington and Sutherland (1956) and water soluble carbohydrates (Dubois et al., 1956) as adopted to corn plant by Johnson et al. (1966).

Statistical analyses

The data were treated by analysis of variance by the general linear model procedure of SAS (1982). For ensiling and digestibility data, block and treatment were included in the model. Orthogonal polynomials were run to test the treatments effect. In digestion trial, the contrasts were; sudex grass silage alone vs waste containing silages; silage containing 40% cage layer waste vs silage containing 30 and 50% cage layer waste and 30% cage layer waste silage vs 50% cage layer waste silage.

RESULTS AND DISCUSSION

Chemical composition

The crude protein (CP) content of cage layer waste was found similar (table 1) to the values reported by Liebholz, 1969; Samuels, 1980 and Flachowsky and Henning, 1990 and higher values were reported by Magar, 1988. Ash contents were higher than the values reported by Flachowsky and Henning, 1990 and lower than the values reported by Magar, 1988. These differences could be due to the time laps between the time of excretion and collection.

Table 1. Chemical composition of broiler litter and rumen contents[1,2], $g \cdot kg^{-1}$

Item	Cage layer waste	Sudex grass
Dry matter	609.0	356.0
Crude protein	290.0	76.3
Ash	300.0	38.5
Cell wall constituents		
Acid detergent fiber	331.2	565.0
Neutral detergent fiber	182.0	285.1
Cellulose	105.0	241.0
Hemicellulose	127.0	271.0
Lignin	38.0	51.0
Water soluble carbohydrates	34.5	71.2

[1] Each value represents the mean of six samples.
[2] DM, basis except dry matter.

Sudex grass like other C_4 tropical grasses was found lower in CP content (76.3 g^{-kg}, DM basis). The water soluble carbohydrates in sudex grass was 71.2 g^{-kg}, DM basis, found sufficient for the ensiling process to take place. Chemical composition was similar for initial and ensiled mixtures. However, initial and ensiled mixtures of grass-waste silages showed linear increase ($p < 0.01$) in DM, CP and ash contents (table 2). This increase was due to higher quantity of these nutrients in cage layer waste. Cage layer waste had 29.2% CP, DM basis. Liebholz, (1969) and Flachowsky and Henning, (1990) reported similar values and further they found that amino acid N of the waste ranges from 37-45% of total N and approximately 50-60% of total N is in the form of NPN. Uric acid is the main NPN component of cage layer waste (Evans et al., 1978). Increased ($p < 0.01$) ash contents with respect to waste addition might also be expected to supply some essential minerals, especially calcium and phosphorus. Supplementation of waste-based diets with minerals is usually not required, because of higher amount of minerals present in cage layer waste, particularly Ca and P (Oliphant, 1974; Westing et al., 1985; Flachowsky and Henning, 1990). The values of water soluble carbohydrates decreased ($p < 0.01$) and pH values increased ($p < 0.01$) for initial mixtures with the addition of cage layer waste (table 3). Ensiling decreased the pH for all mixtures; decrease was higher for sudex grass ensiled alone than for grass ensiled with cage layer waste. The pH values of cage layer waste silages were lower than those reported by Magar, 1988 and Samuels, 1980. Saylor and Long (1972) observed a pH of 5.8 when cage layer waste and ground orchard grass was ensiled in 60:40, ratio, wet basis. Where as Yokoyama and Nummy (1976) reported pH values of 4 and 5.2 for corn forage ensiled alone and with cage layer waste, respectively. Thus the close agreement of the values obtained in present study with the previously reported values indicated that normal ensiling had occurred.

Table 2. Chemical composition of initial and ensiled mixtures of sudex grass and cage layer waste[1,2], $g \cdot kg^{-1}$

Item	Sudex grass : Cage layer waste[3]				
	100:00	70:30	60:40	50:50	SE[4]
Pre-ensiled					
Dry matter[5]	356.0	433.6	459.0	484.0	.21
Crude protein[5]	76.3	141.0	161.8	183.2	.31
Ash[5]	38.5	117.0	143.1	169.4	.41
Post-ensiled					
Dry matter[5]	343.0	427.5	451.0	477.5	.21
Crude protein[5]	78.1	142.5	161.8	190.1	.31
Ash[5]	39.1	121.1	148.3	172.5	.41

[1] Each value represents the mean of six samples.
[2] DM, basis except DM.
[3] Proportion on wet basis.
[4] Standard error of means.
[5] Linear effect of treatment ($p < 0.01$).

After ensiling the increase ($p < 0.01$) in lactic acid and decrease ($p < 0.01$) in WSC concentration for all the treatments indicated that considerable fermentation was achieved (table 3). Lactic acid in silages increased ($p < 0.01$) with the increase of cage layer waste. Buffers, such as higher ash content and ammonia from urea/uric acid hydrolysis, have shown to increase the final lactic acid concentration of ensiled corn forage and poultry waste (Owen et al., 1969; Shirley et al., 1972; Goering and Smith, 1977 and Ayangbile, 1987). High buffering capacity could result in a prolonged fermentation and concomitant build up in lactic acid (Goering and Smith, 1977). The lactic acid concentrations observed in this study principally agree with earlier studies. Water soluble carbohydrates values for silages decreased ($p < 0.01$) with the increase of cage layer waste. During ensiling process, once anaerobic condition is established, anaerobes utilize soluble carbohydrates to produce organic acids, mainly lactic acid and acetic acid. These acids, in turn, lower the pH of silage (McDonald, 1982).

Table 3. Water soluble carbohydrates (WSC), pH and lactic acid concentration of pre-ensiled and post-ensiled mixtures of sudex grass and cage layer waste[1,2], $g \cdot kg^{-1}$

Item	Sudex grass : Cage layer waste[3]				
	100:00	70:30	60:40	50:50	SE[4]
Pre-ensiled					
WSC[5]	69.9	60.2	56.5	52.9	.07
pH[5]	6.34	6.87	6.99	7.00	.02
Lactic acid	0.71	0.00	0.00	0.00	.01
Post-ensiled					
WSC[5]	38.3	22.5	20.1	20.0	.08
pH[5]	4.14	4.95	5.09	5.49	.05
Lactic acid[5]	66.5	69.5	73.5	78.5	.01

[1] Each value represents mean of six samples.
[2] DM, basis.
[3] Proportion on wet basis.
[4] Standard error of means.
[5] Linear effect of treatment ($p < 0.01$).

Biological examination

Total number of colony formig units (CFU) for initial mixtures of sudex grass and cage layer waste showed higher counts for mixtures containing waste compare to sudex grass mixture alone (table 4). Salmonellae, Shigella and Proteus were present in the mixtures containing waste. Following processing all silages tested were negative for total number of CFU, *Salmonellae, Shigells* and *Proteus*. Complete elimination of the organisms has been reported by Samuels (1980) when poultry manure was ensiled with sugar cane bagasse, by Vezey and Dobbins (1975) when cage layer waste was ensiled with corn forage and by Ayangbile, (1987) when cage layer waste was ensiled with wheat straw. Similar finding have been reported by Dobson et al. (1984); McCaskey et al. (1985); Ayangbile, (1987); Magar, (1988); Lober et al. (1992) and Chaudhry et al. (1993).

Heat production during fermentation period contribute to inhibition of Coliform, *Salmonellae, Shigella* and *Proteus* (chung and Goepfert, 1970) and it is well known that *Salmonellae, Shigella* are killed faster at temperature 40-55℃ (Wassen and Strauch, 1976; Van Soest, 1982). In addition some lactobacilli produces sufficient hydrogen peroxide to inhibit Coliform and Salmonellae organisms (Dahiya and Speck, 1969). McCaskey and Anthony (1979) reported that bacteria isolated from ensiled animal wastes inhibit the growth of Coliform, Salmonellae, Streptococci and Staphylococci by a mechanism other than acid production.

Table 4. Total Number of colony forming units (CFU), Salmonellae, Shigella and Proteus of pre-ensiled and post ensiled mixtures of sudex grass and cage layer waste[1]

Pathogens	Sudex grass : Cage layer waste[2]			
	100:00	70:30	60:40	50:50
Pre-ensiled				
CFU[3] (10^6)	0.11	1.15	41.12	62.31
Salmonellae	−	+	+	+
Shigella	−	+	+	+
Proteus	−	+	+	+
Post-ensiled				
CFU[3] (10^6)	0.00	0.00	0.00	0.00
Salmonellae	−	−	−	−
Shigella	−	−	−	−
Proteus	−	−	−	−

[1] Each value represents the mean of six samples.
[2] Proportion on wet basis.
[3] CFU, g, dry basis.
(+) Indicates presence, (−) Indicates absence.

Apparent digestibility

The chemical composition of the diets is given in table 5. Dry matter, crude protein and ash contents were lower ($p < 0.01$) and fiber fractions were higher ($p < 0.01$) for sudex grass silage alone, compared to grass-cage layer waste silages (table 5). Within grass-waste silages, DM, CP and ash contents increased linearly ($p < 0.01$). Differences in the chemical composition of diets containing different proportions of cage layer waste reflected the composition of silages.

All diets were readily accepted by the animals and no digestion disturbances were noted. Among the diets, average digestibilities of DM, CP, OM, and cell wall constituents were lower ($p < 0.01$) for sudex grass silage alone, compared to silages containing sudex grass and cage layer waste (table 6). Among waste containing diets the digestibilities of all the nutrients showed quadratic effect ($p < 0.01$), increased for the silages containing 30 and 40% cage layer waste and decrease ($p < 0.01$) when the level of cage layer waste increased from 40 to 50%. Among waste containing diets, the diet with 40% cage layer waste had higher digestibilities for all the components. Depression in the digestibilities of all the components for diet containing 50% cage layer waste could be due to higher ash contents of the diet. Diets containing 17 to 34% ash contents, DM basis, may lower the digestibilities for all the components (Liebholz, 1969; Lowman and Knight, 1970; Bull and Ried, 1971). Evans et al. (1978) reported that a 33% increase in ash content in diet containing cage layer waste resulted in 14 % decrease in DM digestibility.

Table 5. Chemical composition of diets fed to sheep[1,2], $g \cdot kg^{-1}$

Item	Sudex grass : Cage layer waste[3]				
	100:00	70:30	60:40	50:50	SE[4]
Dry matter[5]	343.0	427.5	450.0	477.5	.48
Crude protein[5]	78.1	142.5	161.8	190.1	.05
Ash[5]	39.1	121.1	148.3	172.5	.18
NDF[5,6]	551.1	480.0	461.3	435.0	.01
ADF[5,7]	270.0	241.2	235.1	227.5	.13
Cellulose[5]	250.0	206.5	190.0	178.1	.03
Hemicellulose[5]	270.0	227.5	215.0	200.0	.01
Lignin[5]	49.9	46.1	45.1	44.0	.04

[1] Each value represents the mean of six samples.
[2] DM, basis except DM.
[3] Proportion on wet basis.
[4] Standard error of means.
[5] Linear effect of treatment ($p < 0.01$).
[6] Neutral detergent fiber.
[7] Acid detergent fiber.

Table 6. Apparent digestibility of sudex grass and cage layer waste silages given to sheep[1,2], $g.kg^{-1}$.

Item	Sudex grass : Cage layer waste[3]				
	100:00	70:30	60:40	50:50	SE[4]
Dry matter[5,6,7]	496.0	502.2	573.0	511.1	.13
Organic mattter[5,6,7]	516.1	596.7	601.1	588.5	.26
Crude protein[5,6,7]	496.7	601.5	631.3	611.7	.02
NDF[5,6,7,8]	501.3	531.1	541.5	511.7	.03
ADF[5,6,7,9]	511.4	511.4	550.1	500.1	.09
Cellulose[5,6,7]	563.3	614.7	631.5	621.5	.83
Hemicellulose[5,6,7]	541.4	601.0	628.5	601.1	.29
Lignin[5]	323.3	301.3	310.1	321.3	.12

[1] Each value represents the mean of six samples.
[2] DM, basis except DM.
[3] Proportion on wet basis.
[4] Standard error of means.
[5] Quadratic effect of treatment ($p < 0.01$).
[6] Grass silage vs waste containing silages differ ($p < 0.01$).
[7] Silage containing 40% waste vs silage containing 50% silage differ ($p < 0.01$).
[8] Neutral detergent fiber.
[9] Acid detergent fiber.

Lower digestibilities of the sudex grass silage for all the components may be associated with low nitrogen contents. Crude protein content below 8% cannot fulfill the nitrogen requirement of rumen bacterial (Van Soest, 1982). Adding nitrogen sources like cage layer waste in tropical C_4 grasses increased the apparent digestibilities for all the components (Magar, 1988; Chaudhry et al., 1993). Smith and Calvert (1976) substituted poultry manure for 0, 50, and 100% of N provided by soybean meal in sheep diets and found no difference in the digestibility of CP among treatments.

The implications of these results for feeding animals are that cage layer waste may be used as a source of nitrogen and minerals. Nutrient deficiencies in developing countries can at least partly be alleviated by feeding upto 40% DM, basis of ensiled cage layer waste. Feeding this waste to ruminants as a feed ingredient will not only provide the nutrients for animals, but will also solve the pollution problems.

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