POULTRY WASTES AS FOODS FOR RUMINANTS AND ASSOCIATED ASPECTS OF ANIMAL WELFARE
— Review —

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Summary

Animal welfare is often neglected by livestock productionists when considering the utilization of animal wastes for livestock feeds.

The present review has been carried out to examine the nutritive value of poultry wastes for ruminants, the health risks involved with feeding it, the treatment and feeding methods and the production responses of animals fed on it. It was found that mineral, crude protein, crude fibre and metabolisable energy concentrations are influenced by the system of poultry production, the storage of the waste and the treatment method. Heating at 60℃ kills all pathogens apart from *Clostidium botulinum* whereas proper ensiling kills all. Apart from the kidney fat and the liver, animal tissues have not shown residues of drugs or heavy metals from poultry wastes. Palatability is affected when the moisture is more than 200 g/kg. Production responses are satisfactory when poultry wastes replace portions of concentrates.

It was concluded that poultry litter generally has higher metabolisable energy contents than poultry manure, but research is needed to classify poultry litters on their energy values. The adverse effects of toxic minerals and drug residues are negligible in balanced poultry waste feeding systems.
(**Key Words**: Dry Matter Intake, Feeding, Health Risks, Liveweight Gain, Poultry Wastes, Treatment)

Introduction

In many parts of the tropics foods that are available in the dry season for ruminants are of low quality and are deficient in crude protein. Protein supplements are generally expensive and non-protein nitrogen supplements are often difficult to obtain. Poultry litter and poultry manure are good sources of non-protein nitrogen and they are cheap. Ruminant animals normally recycle urea in their saliva and the rumen microbes do not require a source of dietary protein. They can utilise sources of nitrogen such as urea and the use of poultry waste conforms to the natural use of such nitrogen compounds by ruminant animals.

The use of poultry wastes as a feed for ruminants has been widely practiced and studied. Noland et al. (1955) were some of the first authors to describe the use of poultry litter as a source of nitrogen for ruminants. Muller (1982) has produced a manual for feeding animal wastes which includes 134 different formulas of rations containing poultry wastes.

As an animal waste product, poultry waste has different nutritive features from other agro by-products. Although it is a good source of crude protein and minerals, the energy values are very variable. Voluntary food intakes and growth rates can either be depressed or increased when poultry wastes are included in the diet (Jakhmola et al., 1988; Tagari, Levi et al., 1976). Feeding poultry wastes is of concern from the animal welfare point of view and health aspects are also considered.

The objectives of this review are to investigate the nutritive value of poultry wastes and the factors that influence it. Health aspects are examined together with treatment methods. Also the ways of feeding poultry waste and production responses of animals fed on it are reviewed.

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Types of Poultry Waste and Chemical Composition

Poultry wastes appear in two different forms; litter and manure. Poultry litter is a mixture of bedding material and excreta which is collected from sheds where birds have been kept on deep litter (Fontenot and Jurubescu, 1980). Poultry manure is pure excreta which is collected from birds which are kept in cages. The composition of the two forms are different.

The chemical composition and mineral contents of poultry litter and poultry manure of various sources are shown in table 1 and 2. The range of crude portein content for poultry manure is between 20 and 28%. Poultry litter has a wider range of 17 to 31%. The range of ash content for poultry manure seems to be much higher than that of poultry litter with values of 28 to 35% and 14 to 24% respectively.

There seems to be marked differences in calcium (Ca) contents, Ca being higher in poultry manure.

Factors that Influence the Composition of Poultry Wastes

The Poultry Production System

The type of poultry, the original food and the bedding material all have major impacts on the composition of poultry wastes (Jakhmola et al., 1988). The more birds that are kept per m^2 and the longer the birds are kept on the litter, the more droppings the litter will contain. This will have an effect on the nitrogen (N) content of the litter. An example of the proportion of droppings in litter is given in table 3. The bedding material can be wood shavings, sawdust,

TABLE 1. CHEMICAL COMPOSITION OF POULTRY WASTES

Type of poultry waste	DM %	CP	Percentage of DM ASH	CF	ADF	NDF	Source
Poultry litter							
Broiler litter	84.7	31.3	15.0	16.8	–[2]	–	Bhattacharya and Taylor (1975)
Broiler litter sundried, from rice husks, 10 weeks matured	–	16.2	18.2	20.0	–		Kishan et al. (1984)
Broiler litter from Rhodes hay	86.5	19.5	13.1	14.4	–	–	Kayongo and Irungu (1986)
Broiler litter sundried, from wood shavings	–	17.9	12.7	–	38.0	–	Odhuba et al. (1986a)
Poultry litter sundried	–	17.1	24.1	23.7	–	–	Singh and Negi (1986)
Poultry litter from sawdust	87.5	25.5[1]	15.6	17.7	–	–	Flachowsky et al. (1985)
Poultry manure							
Layer manure, dried	89.7	28.0	28.0	12.7	–	–	Bhattacharya and Taylor (1975)
Layer manure, sundried, autoclaved	90.3	20.3	27.8	13.4	–	–	Thakur et al. (1982)
Layer manure	–	25.2	–	–	19.0	–	Odhuba et al. (1986b)
Poultry manure, dried	91.5	22.0	35.2	–	–	40.8	Trung et al. (1987)

[1] Samples ranged from 21.0-30.2.
[2] Not available.

TABLE 2. MINERAL CONTENT OF POULTRY WASTES

Type of poultry waste	% of DM						mg/kg on DM Basis				Source
	Ash	Ca	P	Mg	Na	K	Fe	Cu	Mn	Zn	
Broiler litter	15.0	2.4	1.8	0.44	0.54	1.8	451	98	225	235	Bhattacharya and Taylor (1975)
Layer manure	28.0	8.8	2.5	0.67	0.94	2.33	0.2	150	406	463	Bhattacharya and Taylor (1975)
Layer manure	27.8	4.2	1.9	—[1]	—	—	—	—	—	—	Thakur et al. (1982)

[1] Not available.

chopped straw or husks of grains or groundnuts. The type of material affects the digestibility, mineral and protein content of the litter.

Good quality foods will produce manure which is richer in protein and digestible energy than with poorer foods. A high feeding level and high rate of food spillage will result in better feeding value of the waste. The high concentration of calcium in food for layers is probably responsible for the higher concentration of Ca in their manure compared to litter of broilers.

TABLE 3. AVERAGE RATIO OF INGREDIENTS OF POULTRY LITTER

Ingredient	% of PL (DM basis)
Droppings	62
Bedding material	31
Spilled food	3
Feathers	2
Foreign matters	2

Source: Muller (1982).

Storage and Treatment

Wet faecal waste is subject to high proteolytic activity, which results in rapid loss of nitrogen and organic matter and the subsequent increase of mineral matter (Zindel and Flegal, 1970). An increase in moisture content and length of storage therefore decreases the nutritive value of poultry wastes. A typical example of decomposition of poultry litter containing 32% moisture is shown in table 4.

Drying induces losses of the crude protein content of 7 to 22% of the original depending on the drying method (Muller, 1980). Rapid drying at temperatures up to 60℃ would minimize nitrogen losses.

Ensiling prevents crude protein losses to 1% or less of the original quantity. In fact, ensiling converts part of the non-protein-nitrogen into true protein (Muller, 1982). During ensiling, soluble carbohydrates are converted into volatile fatty acids like acetate, butyrate and lactate. Treatment with formalin reduces protein solubility. This will result in a higher undegradable protein content.

Health Risks and Treatment Methods

Organisms

Several pathogenic organisms have been isolated from poultry litter. The bacteria include *Clostridium sp.*, *Corynebacterium sp.*, *Salmonella sp.*, *Actinobacillus sp.*, *Mycobacterium sp.*, *Bacillus sp.*, *Staphylococcus sp.* and *Streptococcus sp.* (Alexander et al., 1968; Hall, 1985).

Clostridium botulinum can cause mass out breaks of bovine botulism such as occurred in Israel and Australia in 1990 (Jones, 1991). These were associated with the feeding of poultry wastes.

Treatment

Heating at 60℃ for one hour kills all organisms (Messer et al., 1971), but spores of *C. botulinum* can survive heating at 100℃ for five hours (Hall, 1985). Autoclaving seems to be an efficient method for killing microbes (Caswell et al., 19 75) but the equipment is expensive.

Lactic fermentation in silage eliminates pathogens

TABLE 4. CHANGES IN UNPROCESSED POULTRY LITTER DURING 28 DAYS OF STORAGE

	% of DM		
	Day 0	Day 14	Day 28
Crude protein	27.2	20.8	16.0
True protein	16.8	11.4	7.1
Ash	2.3	21.9	26.7

(Source: Müller, 1982).

if the pH is sufficiently reduced (Walker, 1984). It appears that ensiled materials should reach a pH of less than five and a temperature of 25℃ or higher in order to destroy *salmonellae* (McCaskey and Anthony, 1975). *C. botulinum* does not grow below pH 5 and the toxin is destroyed below this pH (Jones, 1991). Because poultry waste contains relatively large amounts of Ca, it has a big buffering capacity. It is therefore necessary to add enough carbohydrate while ensiling, in order to get enough lactic acid fermentation and subsequent reduction of the pH.

Stacking poultry litter of less than 35% moisture at 1.5 m depth for six to eight weeks renders the material fairly sterile with no remaining Coliforms, *Salmonella* or *Shigella* (Muller, 1982). The surface material however cannot be considered sterile and would have to be disposed of or heated again.

Treatment with formalin kills bacteria, fungi and larvae. All important pathogens are effectively killed (Muller, 1982). Fresh poultry wastes can be treated with 0.7% formalin on dry matter basis. Poultry litter should contain at least 35% moisture to enable enough contact with the chemical. Since formalin has some adverse effect on the palatibility, molasses is then often added before feeding.

Sun drying is often practised in the tropics for poultry litter. It is an effective way to kill *Salmonella* sp. and *Actinobacillus* sp., since these bacteria are killed by desiccation and sunlight. Poultry manure can be dried on slats underneath the cages of the birds, but this is not sufficient to kill the pathogens.

Drug Residues in Poultry Wastes

Poultry waste can be contaminated with insecticides when poultry have been sprayed against ectoparasites. Insecticides are also fed to poultry to control the insects in the manure (Fontenot and Jurubescu, 1980) or the manure is sprayed directly for this reason. However, feeding of poultry waste at 25-50% inclusion levels for beef cattle did not increase pesticide residues in beef fat (Fontenot and Jurubescu, 1980). Feeding insecticide at 200 parts per million did not result in unusual accumulation in the milk of dairy cows (Miller and Gordon, 1973). So far pesticides in poultry waste have never caused adverse health effects to animals fed on it.

Polyether ionophores, used as coccidiostats, are cardiotoxic and might cause cardiomyopathy (Perl et al., 1991). Fatal cases of primary cardiomyopathy have been reported in beef herds in Israel where some cattle consumed more than 10 kg poultry litter per day as their sole diet (Davidson et al., 1989). Further investigation in this subject is being carried out (Perl et al., 1991).

Webb and Fontenot (1975) carried out a study on the effect of medicinal drugs in poultry wastes on cattle. They found no residues of amprolium or nicarbazin in animal tissues after a five day withdrawal period. A low level of chlortetracycline (0.041 ppm) was found in the kidney fat of a few animals.

Toxic Minerals

Heavy metals like arsenic, copper and selenium are sometimes added to poultry food (Fontenot and Jurubescu, 1980). They are more concentrated in the waste because of their low absorption in the alimentary tract. They could form a hazard to the animals consuming poultry wastes and to the public consuming the animals. Fontenot and Jurubescu (1980) found that none of these metals have caused health problems for ruminants consuming poultry wastes. Arsenic and selenium had no or negligible residues in the animal products after seven days withdrawal of poultry wastes. Liver copper levels increased in lambs and beef heifers when fed poultry wastes.

Methods of Feeding

Whole Food

Poultry litter seems to be palatable enough to serve as a whole food. European beef cattle in Israel have consumed considerable amounts of dried poultry litter while grazing on poor pastures (Perl et al., 1991). Zebu cattle and indigenous sheep in Ethiopia also showed good intakes of fresh poultry litter when supplemented to poor pasture grazing (Flachowsky et al., 1985). The cattle consumed only small amounts of the litter when its dry matter content was below 80%.

At a farm in Nigeria scavenging goats ate the dry material from the surface of stacked poultry litter during the dry season and their condition was much better than that of other scavenging goats who did not have access to poultry litter (personal observations).

In the experiment of Thankur et al. (1982) one group of kids of three to four months old was fed ground dried caged layer manure as a whole diet with jack leaves *ad libitum*. They lost weight which was probably due to insufficient metabolisable energy intake.

It can be concluded that poultry litter serves well as a whole diet as long as the moisture content is not too high. Whole foods of poultry manure are not often used and seem to be less suitable.

Silage

Poultry wastes can be ensiled together with other agro by-products which are rich in energy such as molasses, fruit and vegetable wastes, ground grains and cassava peels. Alternatively forages can be included. It is essential that enough soluble carbohydrates are available to ensure a good fermentation process (Muller, 1982). The moisture content should be at least 40 %. It should not be higher than 75% otherwise clostridial growth is promoted (Jakhmola et al., 1988). The silage can be fed after 21 days. When an appropriate lactic fermentation has taken place the pH should be 3.8 to 5.2 (Muller, 1982; Walker, 1984).

On small farms plastic bags, pit silos or large diameter concrete drain pipes erected on a simple brick foundation with an opening at the base can be used (Muller, 1982). A problem with silage in the tropics is that once it is opened, aerobic fermentation induced by high ambient temperatures can spoil the whole silage. Small silos are therefore preferable, because they are used quickly once opened. Silos with a small opening at the bottom would also seem appropriate for the tropics.

When the moisture content is between 30 and 40% it is called a "dry silage" (Muller, 1982). The material goes through a long initial aerobic process. The high temperatures obtained during this process often kill all pathogens. In well sealed dry silages poultry wastes can be ensiled without any other additives.

Mixing with Other Foodstuffs

Poultry wastes can be mixed with other foodstuffs when it is either fresh or dried. The foodstuffs to mix the poultry wastes with should be rich in energy as poultry wastes are deficient in energy.

Rations should contain enough crude fibre to allow proper rumen functioning. Poultry manure, ground poultry litter or poultry litter based on saw dust should be mixed or supplemented with appropriate amounts of fibrous foods. Non-legume forages are often fed *ad libitum* for this purpose. Chopped straw, sprinkled with a molasses solution can also be mixed with poultry wastes and other ingredients.

Moist mixtures should not be left long before feeding to prevent proteolysis.

Value to the Ruminant

Crude Protein

Between 40 to 60% of the crude protein in poultry wastes is in the form of non-protein nitrogen (Bhattacharya and Fontenot, 1966; Bhattacharya and Taylor, 1975; Jayal and Misra, 1971; Smith et al., 1978). About 30 to 60% of the total N is uric acid and 14% of the total N is ammonia (Bhattacharya and Taylor, 1975 ; Smith et al., 1978). Uric acid is well utilized by rumen organisms and is a better source of non protein nitrogen than urea because ammonia is released at a slower rate (Oltjen et al., 1968).

Energy and Digestibility

Energy values seem to be higher for poultry litter than for poultry manure. Bhattacharya and Fontenot (1966) found that broiler litter with peanut hulls and woodshavings as base materials had 9.4 MJ digestible energy (DE) per kg DM. Poultry manure only contains an average of 7.9 MJ DE (Bhattacharya and Taylor, 1975). This difference is probably a result of the higher ash content of poultry manure. Some digestibility and metabolisable energy (ME) values are shown in table 5. The reported ME value of 9.12 MJ/kg dry matter (DM) is quite high. With lower digestibility values of 0.54-0.63 as reported by Flachowsky et al. (1985) and Muller (1982) the ME will be lower as well. Odnri (1988) recommends a value of 6.7 MJ ME/kg DM for poultry wastes for ration formulation. McDonald et al. (1981) suggested an average ME value of 7.5 MJ/kg DM of poultry litter for practical use.

TABLE 5. DIGESTIBILITY AND ENERGY VALUES FOR POULTRY WASTES

Type of poultry waste	Digestibility DM	Digestibility OM	Digestibility N	ME MJ/kg DM	Source
Broiler litter	0.746	–[1]	0.744	9.12	Bhattacharya and Taylor (1975)
Layer litter, from sawdust	0.630	0.698	0.828	–	Flachowsky et al. (1985)
Layer manure	0.566	0.665	0.777	6.57	Lowman and Knight (1970)

[1] Not available.

Minerals and Vitamins

Poultry wastes are good sources of Ca and P (see table 2). The high Ca content makes it a good ingredient for diets of lactating animals. Mg and Na contents are normal as far as general dietary requirements are concerned.

There seems to be no information on vitamin contents of poultry wastes, but no cases of avitaminosis have been reported of animals fed on poultry wastes (Flachowsky et al., 1985; Arieli et al., 1991).

Palatability and Adaptation

The value of feeding poultry wastes can initially be reduced because of poor palatability. Muller (1982) reported that it normally takes three to five days with a maximum of ten days for ruminants to adapt to diets which contain 30% or less animal wastes on DM basis. Stall fed ruminants would accept the new food more quickly than grazing ones, probably because their feeding is restricted. Poultry litter would increase the palatability of silage to an extent that sheep would consume twice as much silage containing poultry litter than silage without.

In the nutrition trial of Okeke and Oji (1988) West African dwarf bucks took ten days to adapt to silage containing 60% poultry manure on a fresh basis while the maximum intake was reached at 16 days. Stall fed heifers in an adaptation study carried out by Arieli et al. (1991) took three to four weeks to reach maximum dry matter intake of diets containing poultry manure.

Production Responses and Food Intake

In the experiment conducted by Trung et al., (1987), Holstein Friesian-Red Sindhi cross heifers were fed on straw blended with concentrates. Dried poultry manure replaced 0 to 22.5% of the concentrates in different diets. There was no difference in liveweight gain at the different inclusion levels of poultry manure during the period from yearling to breeding and from breeding to calving. The different levels did not affect the total milk production nor the fat corrected milk, over the whole lactation. The voluntary food intake was depressed when poultry manure was included in the concentrates at a level of 45%.

In the experiment of Kayongo and Irungu (1986) grazing Friesian heifers received concentrates with inclusion levels of poultry litter ranging from 0 to 30%. The different levels did have no effect on milk yield or milk composition. Daily liveweight gain was not affected.

In a growth trial of sheep on straw based diets by Lal et al., (1986), liveweight gain over six weeks was not affected when poultry litter replaced 25 to 75% of the concentrates. The daily dry matter intake was similar for all diets.

Thakur et al. (1982) reported a decrease in liveweight gain in kids fed jack leaves *ad libitum* when 30% dried poultry manure was included in the concentrate mixture. However, dry matter intake was not affected.

In the experiment of Flachowsky et al. (1985) grazing Boran bulls and Ogaden sheep which were fed poultry litter at night had a higher average liveweight gain than the ones which did not receive poultry litter. No statistical tests were used though. During the dry period of the feeding trial the grass was very deficient in protein (6.5% CP on DM basis) and the beneficial effect of poultry litter was probably in the supply of extra crude protein.

Conclusion

The review has indicated that poultry wastes can make an important contribution as an animal feed, but that there are animal health and welfare aspects which deserve the fullest attention. The composition of poultry wastes depends largely on the system of poultry farming, the length and way of storage of the waste and the treatment method. Their energy values are low, but are better for litter than for manure. In the tropics, where bedding materials of a better digestibility are used, metabolisable energy contents of poultry litter are probably higher. More research is needed to determine metabolisable energy values of poultry litter from different sources.

Although proper ensiling of poultry wastes takes several weeks, its advantage is that it kills all pathogens and reduces the adaptation period. Heating at 60°C would be sufficient to kill most pathogens apart from *C. botulinum*. Sundrying kills some important pathogens. When low heat treatment or sundrying are practised as a safety measure, it would be advisable to vaccinate the animals which are fed on the poultry waste, against botulism.

Toxic minerals or drug residues do not create risks for the animals or consumers of their products, when sufficient roughage is fed to the animals and when a withdrawal period of one week is observed. However, the liver and kidney can have increased concentrations of copper and medicinal drugs.

Because ammonia is only slowly released from proultry wastes it provides a more continuous ammonia pool in the rumen than other NPN sources. This makes it a useful N supplement for diets based on low quality roughage which is deficient in N. Live weight gains and milk production are not affected when poultry manure replaces up to 23% of the concentrates. Voluntary food intake decreases when more than 30% is included. Poultry litter however can replace up to 75% of the concentrates without affecting voluntary food intake or live weight gain. When diets are deficient in crude protein, supplementation of poultry litter increases the live weight gain.

The sometimes long adaptation period needed by animals introduced to poultry litter could cause hesitations by farmers to use it. When poultry wastes are replacing protein concentrates therefore, small amounts of poultry wastes should be introduced at a time, in order not to put the animals off their food.

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