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Factors Limiting Use of Poultry Manure as Protein Supplement for Dairy Cattle on Smallholder Farms in Kenya

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Abstract: Productivity of ruminant animals during the dry season, on smallholder farms in Kenya, is constrained by low availability and poor quality of the feeds (crop residues). The current study was conducted on smallholder farms in Nakuru, Koibatek and Trans Nzoia Districts in 2003 over 2-year period preceded by a 6 - week feed survey. The objective of the feed survey was to inventorize feed resources available on smallholder resource - poor farms and delineate factors limiting their optimization for enhanced dairy production. Other farm bio-data including livestock population (ruminants and poultry) and structure per farm were also collected. This paper confines its discussion on both qualitative and quantitative information gathered during the survey with special focus on poultry manure vis a vis litter and compares the results with reports other research works. During the survey, composite samples of feed resources being utilized at farm level (including poultry manure) were collected for dry matter (DM) determination and proximate analysis at the National Animal Husbandry Research Centre (NAHRC/Naivasha/Kenya). Results obtained, strongly indicated that, poultry manure has great potential for use during the dry season as a source of rumen degradable protein or non-protein nitrogen (NPN) in ruminant nutrition. Though heterogeneity was observed in the many reports reviewed and compared with the current study, the general consensus was that poultry manure/litter contains high level of crude protein (15 to 38%), fiber (11 - 52%), and rich in minerals (Ca: 0.81 - 6.13%; P: 0.56 - 3.92; K: 0.73 - 5.17), dry matter (61 - 95%). It is because of these nutrients that poultry manure has been deliberately mixed into ruminant livestock diets. Its Organic matter digestibility (OMD) ranges from 60 to 65, crude protein (CP) - 69.9, crude fibre (CF) - 29.9 and nitrogen-free extract (NFE) - 71.4%. Past research studies recorded *in vitro* dry matter digestibility (IVDMD) and IVOMD of 76.1 and 72.7%, respectively. Other reports also showed that, beef cattle fed poultry manure based diets recorded body weight gains ranging from 0.91 to 1.31 kg/d. Dairy goats supplemented with poultry manure registered 10.15% higher milk production compared to those on barley based diets (621 and 558 kg, respectively). Based on the available research information, it is conclude in this study that poultry manure can be successfully included in ruminant diets. The constraint, as revealed in the current study is that smallholder farmers do not own large chicken flock sizes (majority own less 30 birds) to guarantee sufficient supply of manure for ruminant feeding. It is this particular factor that is being attributed to the low poultry manure reported in the current study (regular users - 19%; occasional users - 17% and none users - 64%). Where available, poultry manure is very cheap. Since it is cheaply available (not readily) at farm level, poultry manure offers a cost effective option for meeting dairy cattle protein requirements. However, some precaution must be taken to minimize nitrogen loss (which occurs in the form of NH₃, N₂O and N₂) and accumulation of pathogens (*Salmonella* and *E. coli*).

Key words: Nitrogen loss, poultry litter/manure, ruminants, weight gain, digestibility

Introduction

Improvement of livestock production in many developing countries is militated against by a myriad of factors. Of the major constraints limiting the increased livestock production on smallholder resource - poor farms in these countries is the inadequacy of animal feed resources, especially during the dry season. The increased productivity of ruminant livestock on these farms during the dry season is severely constraint by low

availability and poor quality of the feeds. During this time of the year, smallholder dairy herds rely heavily on roadside natural grass' standing hay and crop residues (primarily maize stover) both of which are very low in nitrogen content. For dominant natural grasses such as *Themeda triandra* (Red oats), crude protein content can be as low as 2% during the dry season. Maize stover, like many other crop residues are equally devoid of most essential nutrients including proteins, energy, minerals

and vitamins, which are required for, increased rumen microbial fermentation and improved performance of the host animal. Low nitrogen (N) intake limits the utilization of crop residues as source of energy (Crowder and Chheda, 1982). This is due to low supply of nitrogen to the rumen microbes. Thus, the low crude protein content cannot support rumen microbial function, which requires a minimum of 7% crude protein. Under protein deficient diets, dry matter intake and digestibility in turn fall below requirements for maintenance, leading to decreased milk yield and weight losses. It is, however possible to minimize these losses through protein or non-protein nitrogen (NPN) supplementation. No doubt, quality legumes remain the best option for resource - poor farmers. This is because commercial protein sources that could supplement these low quality feeds are beyond the reach of resource - poor farmers (FAO, 1985; Valk, 1990). The role of legumes, as protein supplements, is however drastically diminished during the dry season. Use of urea and urea molasses mixtures have also been introduced as an alternative means of improving the nitrogen supply to the rumen microbes. However these sources are equally expensive to most farmers and they in addition, impose danger of toxicity especially the use of urea. Another potential protein resource is poultry litter/manure (Fontenot, 1990). Most poultry litter/manure contain about 25% crude protein on a DM basis, about half of which derives from uric acid, which can be efficiently used by rumen microbes for protein production. In addition, poultry manure contributes significant amounts of Ca, P, K, and numerous trace minerals (Ruffin and McCaskey, 1990). If the diet consists of at least 20% poultry manure, no additional mineral supplementation is needed (Gerken, 1990). It has also been shown that poultry litter has a valuable role as a source of NPN for ruminants (Ensminger and Olentine, 1978; Perry, 1980; Hadjipanayiotou, 1984) provided it is processed well in order to destroy potentially harmful microorganism (Rogers and Poore, 1994). Poultry manure may be an effective and economical protein and mineral supplement in smallholder farms. This study examined the extent of poultry manure use and attempts to elucidate factors limiting its utilization on smallholder dairy farms in Kenya.

Materials and Methods

The study was conducted on smallholder farms in Nakuru, Koibatek and Trans Nzoia Districts in mid 2002 to mid 2004. It comprised of two phases (a 6 - week feed survey, followed by 2 - year animal performance data collection period). The objective of the feed survey was to inventorize feed resources available on smallholder resource - poor farms and delineate factors limiting their optimization for enhanced dairy production. Other farm bio-data including livestock population (ruminants and poultry) and their structure per farm, were also collected. This paper confines its discussion on both qualitative

and quantitative information gathered during the survey with special focus on poultry manure vis a vis litter use for ruminant feeding and compares the results with reports from other research works. The survey covered six sites (Naivasha and Solai/Nakuru; Bahati and Rongai/Nakuru; Timboroa/Koibatek and Kaplamai/Trans Nzoia near Mt Elgon). A structured questionnaire was administered to gather both qualitative and quantitative baseline information. In each site, approximately 30 households were interviewed using a line transect approach. During this exercise, administrative and/or public utilities (cattle dips, divisional headquarters and chief camps) were taken as the starting points for the 4 transect walks (East, West, South and North of about 5-7 Km each) for each site. The assumption, were that these points were located at the centre of farming communities in each of the chosen study sites. Every farm household falling on the transect line was interviewed (depending on farmer's presence on-farm at the time and willingness to be interviewed). Representative samples (approximately 500 g each) of feed resources being utilized at the time were collected for dry matter (DM) determination and proximate analysis at the National Animal Husbandry Research Centre (NAHRC/Naivasha/Kenya. Nitrogen content was analyzed by the Kjeldahl method (Crude protein was estimated as $6.25 \times \%N$). Dry matter (%DM), Acid detergent fibre (%ADF), neutral detergent fibre (%NDF) and acid detergent lignin (%ADL) were determined according to Van Soest *et al.* (1991), AOAC (1988) and (Abdulrazak and Fujihara, 1999). Hemicellulose and cellulose were also determined (Abdulrazak and Fujihara, 1999).

Results and Discussion

The nutrient content of poultry manure has been widely studied. The general agreement in all past research reports is that the nutrient in manure will vary from farm to farm depending on the quality of the ration offered to the birds, their age, amount of feed wasted, the amount of water spillage and more importantly, the type and amount of bedding used. Table 1 compares the chemical composition and digestibility of chicken manure samples collected from smallholder farms (where it is being used to feed dairy cattle) and those reported by Trevino *et al.* (2002).

Other than for protein concentration, the results of the current study compares well with past research works which showed that crude protein content of poultry manure from intensive commercial farms ranges from 20 to 25% for crude protein, 55 to 60% TDN, 20 to 25% ash with significant levels of calcium, phosphorus and other macro and trace minerals (Ruffin and McCaskey, 1990). Other research workers have also reported organic matter digestibility (OMD) ranging from 60 to 65, crude protein (CP) - 69.9, crude fibre (CF) - 29.9 and nitrogen-free extract (NFE) - 71.4%. Apparent digestibility of peanut hull and wood shaving broiler manure/litter

Table 1: Proximate analysis and digestibility of poultry manure/litter collected from smallholder farms in Kenya and those reported by Trevino *et al.* (2002)

Components (DM basis, %)	Current study	Trevino <i>et al.</i> (2002)
Dry matter (DM)	94.3	85.7
Ash	20.5	18.6
Organic matter (OM)	85.8	81.4
Crude protein (CP)	15.4	31.6
Neutral detergent fibre (NDF)	36.2	28.9
Hemicellulose	17.1	15.2
Acid detergent fibre (ADF)	19.2	14.8
<i>In vitro</i> dry matter digestibility (IVDMD)	nd	76.1
<i>In vitro</i> organic matter digestibility (IVOMD)	nd	72.7

nd – Not determined

mixture with sheep were reported to range from 70.4 to 73.5% for crude protein, 66.1 - 71.5% (CF), 56.3 - 62.7% (Ether extract), 63.1 - 64.8% (NFE), 61.5 - 66.1% (DM) and 63.1 - 64.8% for gross energy (GE) (Bhattacharya and Fontenot, 1966). These studies further revealed that, depending on the management and feeding regime, poultry manure contains a wide array of minerals. These include phosphorous (P: 0.56 - 3.92%), potassium (K: 0.73 - 5.17) and calcium (Ca: 0.81 - 6.13). Others include: magnesium (Mg), sulphur (S), manganese (Mn), copper (Cu), zinc (Zn), chlorine (Cl), boron (B), iron (Fe), and molybdenum (Mo). Most of these nutrients originate from the feed, supplements, medications, and water consumed by the birds (Paul *et al.*, 1993).

On ruminants feeding value aspect, results of many experiments around the world indicate that dried or ensiled poultry litter can be successfully included in the ruminant livestock diets as a protein supplement (Fontenot, 1990). Other reports also showed that, goats on the poultry manure diet produced significantly more milk (621 vs 558 g/d) compared to those on the concentrates diet (Hadjipanayiotou *et al.*, 1993). Table 2 presents performance of Holstein bulls fed three levels of poultry litter (Trevino *et al.*, 2002).

The daily gains and feed intake results presented in Table 2 are in agreement with those from research works reported by Vijchulata *et al.* (1980: gain - 1.31 kg/d and intake - 7.99 kg DM/d), Koenig *et al.* (1978: 1.29 kg/d and 7.43 kg DM/d), Cullison *et al.* (1976: 1.11 kg/d and 8.77 kg DM/d) and Clarke *et al.* (1975: 0.91 kg/d and 8.7 kg DM/d, respectively). Uric acid is the principle N component of poultry excreta. It is reportedly degraded more slowly than urea, creating a favourable ammonia pattern for efficient utilization in ruminant (Oltjen *et al.*, 1968; McDonald *et al.*, 1988) by rumen microbes for protein production. This may prevent rapid absorption of ammonia from the rumen which can overtax the ability of the liver to re-convert it to urea, hence cause the ammonia concentration of peripheral blood to reach toxic levels (McDonald *et al.*, 1988). The same study further reported that poultry manure use as protein supplement for ruminant livestock, is also limited by low

energy content arising from the low quality bedding materials used in poultry production facilities. Use of bedding material, which is also degradable in the rumen, could improve the overall feeding value of poultry manure. Though Ruffin and McCaskey recommend ruminant livestock diets supplements with 50:50 poultry litter:maize ratio to attain improved animal performance, it has been proven that inclusion of more than 30% poultry manure in the ruminant diet will lead to decreased feed intake and digestibility. For this reason an optimum supplementation levels for dairy cows is 1 to 2 kg daily.

The current study revealed that, despite the positive attributes of using poultry manure as ruminant protein supplements, its use on smallholders in Kenya is extremely low (Fig. 1). Of the many possible underlying factors, low economic status of majority of smallholder farm households is the primary obstacle to increased poultry production and manure use as ruminant feed. Sufficient poultry manure can only be obtained in farm situations where intensive commercial poultry production exists in high proportion. Because of costs involved, compounded by unreliable market and the ever-increasing rural population growth accompanied by dwindling natural resources, commercial poultry production amongst smallholder farmers in Kenya is not common. Production of poultry manure is therefore, far below the current demand. The poultry production practiced by many farm households, in most rural areas in Kenya, is based mainly on free scavenging systems dominated by indigenous chicken. This is a subsistence and a low input/output poultry production practice which has been a traditional component of smallholder farms for decades and is likely to continue as such far into the future. Majority of households interviewed own less than 30 indigenous birds and no exotic breeds (Fig. 1). Although indigenous chicken are characterized by low productivity (30-80 small eggs per hen per year, high chick mortality rates, low body weights, etc.), they are hardy: tolerant to diseases and used to poor nutrition (Muchenje and Sibanda, 1997; Lambrou, 1993), hence their popularity on smallholder resource - poor farms in

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Table 2: Performance of Holstein bulls fed with three levels of poultry litter (Trevino *et al.*, 2002)

Parameters	Levels of poultry manure (%)			CV (%)	Prob.
	0	15	30		
Live weight (kg)					
Initial	1214.0	224.4	211.5	17.2	0.80
Final	318.03	27.03	18.0	6.6	0.55
Average daily gain (kg)	1.17	1.27	1.17	20.6	0.55
Feed intake (kg/head/d)	6.71	7.07	7.34	10.5	0.01*

Table 3: Nitrogen losses from litter storage methods and typical moisture contents (calculated on dry matter basis, Barker, 1990)

Type of storage	Moisture content (%)	NH ₄ -N loss (%)	Total N loss (%)
Uncovered pile	39 - 47	21	30
Covered pile	16 - 19	13	17
Stacking shed	7 - 15	11	26

Kenya. By virtue of the system under which they are reared and their small flock sizes per farm, their potential contribution in terms of manure is insignificant. Over 95% of the farm households interviewed were aware that poultry manure is widely used as ruminant feed and expressed enthusiasm to use so as it is available. Their enthusiasm towards use of poultry manure as a protein supplement for dairy cattle is believed to have been prompted by the chronic lack of protein supplements compounded by the high prices of commercially compounded concentrate. Lack of availability is currently the main setback.

During the current study, it was observed that those households which use poultry manure to compound homemade dairy rations, could be losing more than 75% of the total manure nutrient worth through volatilization, leaching and rotting. This was evidenced by the observed ashy gray appearance, which indicated a loss of nutrient value. More than half of the excreted nitrogen in poultry waste is lost from the housing facility and further losses occur through poor manure handling (conservation). Large losses of manure nitrogen occur through the ammonia and nitrous oxide that are emitted into the atmosphere and the nitrate leaching into the soil (Table 3).

Majority of smallholder farmers in Kenya use air-drying as a mean of increasing the manure's shelf life. After drying the manure is stored in open heaps or highly perforated gunny bags. Drying of manure results in loss of nitrogen (Jakhmola *et al.*, 1988) (Table 3). Manure stored outside and exposed to the weather will decompose rapidly. The N and organic matter will be greatly reduced and K may be lost due to leaching. This strongly concurs with works reported by Eghball and Power (1994), Groenestein and van Faassen (1996), Bierman *et al.* (1999) and Oenema *et al.* (2001) who also reported 10-50% N loss under the same preservation conditions.

It is worth noting here that, when poorly handled, poultry manure can be a source of hazardous contaminants (hard objects, debris, harmful organisms) thereby posing serious danger not only to the ruminant livestock feeding on it, but also to humans who depend on these animals for products such as milk. Two of the main serious obstacles to the feeding of poultry excreta to ruminant livestock, especially where farmers have little knowledge on proper manure handling such as it is on smallholder farms in Kenya, are pathogenic organisms and medicinal drugs. In temperate countries, almost all of these risks can be minimized through proper manure handling. Raw poultry manure contains many potentially harmful pathogens, such as *Salmonella* and *E. coli*, which can be harmful to cattle. Fortunately, all of these potentially harmful bacteria can be killed with mild heat (60°C) which can be generated naturally if manure piles are properly covered to minimize N loss and oxygen entry. Though ensiling of the poultry manure is a simple and widely accepted as the appropriate method of manure conservation, it is hardly practiced in Kenya. Ensiling helps in destroying harmful micro-organisms possibly present in the manure and maintains its nutritive value. Most antibiotic fed to chicken in intensive systems are not a problem when the manure is fed to cattle. Many of the antibiotics are degraded by micro-organisms present in the manure during processing (i.e. ensiling). Essentially, all the antibiotics approved for chicken are also approved for cattle. The other source of risk is mycotoxin. Mycotoxins, such as aflatoxin, are not a cause for concern if manure processing methods, such as deep - stacking and ensiling, are employed. These processing methods help in curtailing mould growth. Moulds that produce mycotoxin do not grow well in properly conserved manure because it is alkaline and the ammonia released is also toxic to moulds. Rapid mould colonization occurs when the quality of the manure

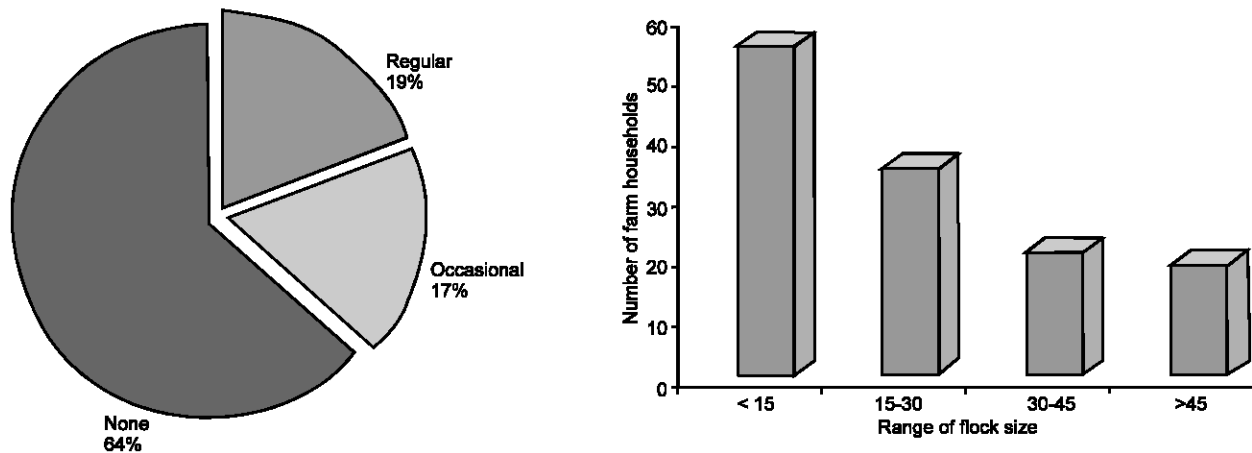


Fig. 1: Smallholder farm households stratified according to poultry manure use as dairy cattle feed and the chicken flock size owned

deteriorates as a consequence of poor handling. Some poultry manure also contains nails, pieces of wire, rocks, screws, and other debris. These need to be thoroughly sifted out before this material is fed to cattle.

Conclusion: In spite of the importance attached to poultry manure as a ruminant protein supplement in many part of the world, little effort has been put to improve its use on smallholder farms in Kenya. This has consequently led to massive wastage through decomposition, quality loss and often mycotoxin contamination. It is concluded here that, in order to increase smallholder farm incomes from ruminant livestock (dairy in particular), an adequate low-cost energy and protein supplementation option must be identified. Numerous research studies have proven that, poultry manure has the potential to replace many expensive grain meal-based protein supplements and as a substitute for legumes during the dry season, thus decreasing feed costs and sustain higher ruminant livestock productivity. Farmers can get maximum feed value when the manure is protected from the quality deteriorating factors (rain, strong sunshine/winds) through proper handling. The problem of low energy content in poultry manure, as pointed out in the discussion, can also be eliminated through incorporation of bedding materials such as maize stover and straws, which are readily utilized by ruminants. Ensiling of poultry manure is simple and since it is the sure way to maintain quality as well as effectively reducing harmful micro-organisms, smallholder farmers should be trained and encouraged to practice it. It is also demonstrated that, silage made from poultry litter, chopped root crops and bananas by-products provides a balanced diet for dairy cows. This can be particularly handy during the dry season when feeds are scarce.

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