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Poultry Litter Selection, Management and Utilization in Nigeria

[1]W.I. Musa, [2]L. Sa'idu, [2]B.Y. Kaltungo, [1]U.B. Abubakar and [1]A.M. Wakawa
[1]Department of Veterinary Medicine, Ahmadu Bello University, Zaria, Nigeria
[2]Veterinary Teaching Hospital, Ahmadu Bello University, Zaria, Nigeria

Corresponding Author: W.I. Musa, Department of Veterinary Medicine, Ahmadu Bello University, Zaria, Nigeria

ABSTRACT

The introduction of commercial poultry in Nigeria has rapidly revolutionarised the poultry industry over the years. This has increasingly raised concern in poultry waste disposal. About 932.5 metric tonnes of commercial poultry manure are annually produced in Nigeria. Ammonia gas is majorly a product of poultry manure and to some extent green house gases. Pathogenic microorganisms can thrive in poultry wastes. These constitute environmental and health hazards to livestock and the teeming population. The concern on how to manage poultry wastes under intensive production systems led to the discovery of suitable poultry droppings and moist absorbents referred to as litter materials. Caging birds may soon become unethical, wood shavings and saw dust are most popular but are increasingly used to manufacture other wood products, alternative litter materials are seasonally available, poultry litter is effectively utilized as nitrogen based fertilizer and livestock feed supplement, therefore, the demand and price for litter materials is magnified. Thus, farmers cannot secure enough good quality litter material for their birds. Economic losses due to poor litter are significantly high. In view of these therefore, careful selection, adequate management and proper storage and utilization of poultry litter are of paramount importance to reduce environmental pollution, disease spread and economic losses associated with poultry litter.

Key words: Poultry, proper storage, economic losses, litter materials

INTRODUCTION

Many individuals and organizations worldwide rely upon the poultry industry for substantial portion of their income and low-cholesterol animal protein intake (Adene, 1989; Moore *et al.*, 1996). The introduction of commercial poultry in Nigeria resulted into its rapid evolutionary changes (Adene, 1997). Breeders and broilers in most countries are raised exclusively on deep litter system (Durojaiye *et al.*, 1991; Embury, 2004). This rapid growth of the poultry industry has increasingly raised concern of poultry waste disposal (Moore *et al.*, 1995). In Nigeria, about 932.5 metric tonnes of commercial poultry manure was reported to be annually produced (Adewumi and Adewumi, 1996; Adewumi *et al.*, 2011). The current poultry manure annual production record in Nigeria appears to be unknown but is expected to be multiples of the above figures. Ammonia and green house gases produced by poultry litter have negative impact on the environment (Meda *et al.*, 2011).

The concern on how to manage poultry wastes under intensive production systems led to the discovery of suitable poultry droppings and moist absorbents called litter material (Asaniyan *et al.*, 2007). At present, the animal welfare organizations frown at caging poultry, wood based litter materials are now being diverted for the manufacture of other wood products while alternative litter materials appear to be seasonal (Charles, 2005). This means that first, deep litter system may be favored and the demand and cost of litter materials magnified (Charles, 2005). Secondly, the requirements for adequate litter materials will not be met and or the litter materials once in abundance will become scarce or unobtainable (Embury, 2004). The implication is that farmers cannot secure enough good quality litter material for their poultry (Adene, 1989), with a detrimental effects on poultry performance.

Economic losses associated with poor litter in poultry include foot and leg problems, respiratory infections, poor weight gain and feed conversion (Charles, 2005; Musa *et al.*, 2012). Cost of poultry waste disposal not normally captured in production budgets may contribute significantly to overall production expenses (Doye *et al.*, 2009). In some countries, old litter is removed and replaced with new one after many sets of birds are grown (Kelley *et al.*, 1995), this is not the case in Nigeria because of poor quality structures, poor management practices and frequent weather variations which necessitate frequent litter change (Sa idu *et al.*, 2008).

Poultry litter contains high nitrogen and phosphorus making it a very good organic fertilizer and feed supplement (Ndegwa *et al.*, 1991; Wood, 1992; Moore *et al.*, 1996; Leo *et al.*, 2009; Doye *et al.*, 2009). However, poultry litter may contain pathogenic microorganisms, drug residues and hard or metallic objects that are injurious to crops, poultry, humans and other domestic animals (Collins *et al.*, 1989; Kelley *et al.*, 1995; Doye *et al.*, 2009; Musa *et al.*, 2009; Musa *et al.*, 2011, 2012; Musa and Sai'du, 2012). This study discusses aspects of selection, proper management, storage and efficient utilization of poultry litter.

SELECTION OF POULTRY LITTER MATERIALS

Researchers have identified sand, pine shavings, shredded papers or paper chips, dry straw, rice hulls, maize cobs, corn silage, peat as alternative litter materials (Ibrahim and Abdu, 1992; Asaniyan *et al.*, 2007; Beri, 2011). Basic requirements of good litter include moisture holding capacity, microbial tolerating ability, low cost, availability and nontoxic to poultry (Shannaway, 1992; Jesse, 2004). Good litter materials are expected to Protect and insulate the bird from dirt, damp and cold floor; conserve heat and should be moisture and faecal absorbent to provide warm soft and spongy surface for optimum comfort of the birds (Ruszler and Carson, 1968; Jesse, 2004). In Nigeria, wood shavings (soft and hard) are available year round from the wood work and furniture enterprises, it is the commonest poultry litter material which today is characterized by periodic shortage due to increasing number of poultry producers (Dafwang, 1990). Unfortunately, hard wood shavings are reported to poorly absorb moisture and are frequently contaminated with *Aspergillus* (Charles, 2005; Musa and Sai'du, 2012), showed highest prevalence of Salmonella organism (Beri, 2011) and posed a significant problem when obtained from chemically treated woods (Embury, 2004). Poultry consumes as much as 4% of their diet as litter and so saw dust is likely consumed which may lead to nutritional deficiency, starvation and mortality (Jesse, 2004; Charles, 2005). Sawdust is most popular litter material in some nations, but it is subject to regular caking around drinkers and feeders (Charles, 2005; Mijinyawa and Dlamini, 2006), has high moisture holding ability and commonly contaminated with *Aspergillus* (Charles, 2005).

In Nigeria, majorly big poultry producers can afford to buy large quantity of wood litter materials while small producers are forced to use insufficient amount of litter due to cost and scarcity (Dafwang, 1990).

Rice hulls work well as litter material because they are free from dust, have high thermal conductivity, drying rate and compressibility (Embury, 2004) but may be costly and restricted to certain regions, easy molding and bacterial growth restrict its use (Jesse, 2004; Charles, 2005).

Corn silage was found to be suitable alternative for common litter material with very low Salmonella prevalence (Beri, 2011).

Straw is any grass material used as litter material. It is however difficult to manage and easily cakes (Jesse, 2004). To be an efficient litter material, straw should be chopped to one inch or less because long straw tends to bridge or mat quickly (Jesse, 2004). Alternatively, straw can be effectively used as a top dressing over old litter; it is cheaper than most litter materials and readily available hence more economically viable (Jesse, 2004). Straw can best be used half and half mixture with shavings, rice hulls or old litters (Jesse, 2004).

Chopped straw was found to be free of Salmonella but had side effects on the health and environment (Beri, 2011).

Bagase, is a sugar cane by-product when sugar is extracted. It is common but not readily used as litter in northern Nigeria; it is highly moisture absorbent and dries easily, however it cakes easily (Jesse, 2004).

Recycled papers like newspapers, cardboard, shredded papers and chopped news papers are gaining importance as alternative bedding materials in poultry industry because of their relative cheapness and availability from paper related industries. However, paper products hold high level of moisture which frequently cakes and increases chances of breast blisters and other carcass defects (Jesse, 2004). Paper based litters were best applied as top dressing or mixed with other conventional wood litter materials (Jesse, 2004).

Pine shavings and sand as separate litter materials were successfully used and had no variations on broiler performance (Asaniyan *et al*., 2007) while sand as litter reduced darkling bee populations, had longer period before clean-out (up to 5 years) but would not heat up appropriately during cold periods when compared to shavings making it suitable material during the summer (Jesse, 2004; Asaniyan *et al*., 2007). Sand is not compatible with composting, incinerating and pelleting but is currently attracting research interest in many places (Jesse, 2004; Asaniyan *et al*., 2007).

Composted or heat treated litter is cheap, dust free, associated with low odor and low pathogenic organisms or parasites and therefore appears to be good and suitable litter, but not recommended for brooding (Embury, 2004). Old litter treated by the heat process produced a bedding material suitable for rearing turkeys and could be incorporated into livestock feeds (Grimes *et al*., 2003; Owen *et al*., 2008a).

Finally, each type of bedding material is subject to factors that will enable it to be a successful litter material (Charles, 2005).

LITTER MANAGEMENT

A good litter is started using adequate materials applied to a depth of at least 2 cm (Cool sand), 5-10 cm (wood shavings), 10 cm (chopped straw) and 8 cm for any other litter material on a dry damp-free floor (Moore *et al*., 2004; Asaniyan *et al*., 2007). Environmental and indoor conditions of poultry houses (temperatures flock density and air movements) have significant influences on litter quality and NH_3 emissions (Terzich *et al*., 1998; Meda *et al*., 2011). Birds pass out concentrated waste (uric acid) making it possible to house a lot of birds on litter with the major problem of only moisture buildup (Jesse, 2004; Asaniyan *et al*., 2007).

Deep litter management despite its importance seems to be neglected in poultry industry in Nigeria (Ezeokoli *et al.*, 1984). For a litter to be well managed, considerations must be given to such factors as: type of litter used at the time of the year, depth of the litter, floor space per bird, feeding and watering devices, kind of floor, ventilation system, routine litter management practices, litter amendment procedure and incidences of disease that can have effects on litter value (Asaniyan *et al.*, 2007).

Depth of the litter varies with the type of litter material in use and will influence performance particularly if it prevents dust bathing (Moore *et al.*, 2004; Asaniyan *et al.*, 2007). High stocking density leads to decreased water and gas exchanges between air and litter (Meda *et al.*, 2011), high chances of feed and water spillage due to space competition, high secretions and excretions in the litter, high temperature and ammonia build up in the poultry house and subsequently high chances of bad litter occurrence, but naturally well ventilated poultry houses with relatively light stocking densities maintain a good litter (Anonymous, 1990). Litters if well managed can be changed between crops (Anonymous, 1990) or commonly changed when they appear bad or following diseases outbreaks in most places. Poor litters are dusty, wet and cake easily (Anonymous, 1990). A good litter should adhere slightly and easily breaks up when dropped from the hand, but when litter is too wet it normally balls up if squeezed in the hand, too dry litter does not normally adhere (Anonymous, 1990). Litter materials on earthen floors have been reported to hold as much as 10% moisture making it almost impossible to effectively manage than litters on damp-proofed concrete floors (Terzich *et al.*, 1998). If the back of the hand feels damp when applied onto a litter, then it possibly contains at least 30% moisture which encourages breast blisters, rapidly converts uric acid to toxic ammonia and supports the growth of fly larvae and coccidian organisms (Anne, 2007).

Litter management has few rules but most decisions are subject to operator's judgment. Litter materials should be checked for bacterial and fungal contaminations, fine particle litter materials should be covered with paper to avoid litter eating, treat new litter material with approved antifungal agents while litter intended to be reused should also be treated with lime (Anne, 2007). Special attention should be paid to drinker points, such areas are liable to caking and should be rototilled to activate litter or removed and fresh litter material added (Sanjay *et al.*, 2006; Anne, 2007). However, tilling of litters is frequently associated with rapid increase in ammonia levels in poultry houses and therefore should be done with windows open or fans on to rapidly dissipate the ammonia ((Anne, 2007). A working litter warms the poultry house while a wet litter cools the house by taking away heat in the process of drying out (Ruszler and Carson, 1968). Ammonia build up beyond 40 Part Per Million (PPM) is potentially dangerous to the birds and the operator (Ritz *et al.*, 2004). The consequences in birds include decrease feed intake and productivity, respiratory tract infections and blindness (Wheeler *et al.*, 2004). Ammonia levels of 15-20 PPM is acceptable and can be estimated fairly accurately by using the operator's sense of smell or litmus paper or more accurately using a dragger gas detector which is commercially available (Xin *et al.*, 2002).

AMMONIA MANAGEMENT IN POULTRY FARMS

Micro-organisms in the litter convert bird's excreta and spilled feeds to ammonium (NH_4^+) which is soluble in water and is convertible to ammonia in the presence of high pH and temperature (Sanjay *et al.*, 2006). On the other hand a high ammonia level in litter is reported to increase fertilizer value but with a consequence of environmental pollution posing health hazards to neighbors (Sanjay *et al.*, 2006). Ammonia in the presence of rainfall contributes to soil acidification and also facilitates algae growth in water bodies (Sanjay *et al.*, 2006). Today there is growing concern in regulating ammonia emissions from livestock worldwide (Sanjay *et al.*, 2006). The concept of litter amendments has shown drastic reduction of ammonia levels in poultry houses thereby improving birds' health and performance (Sanjay *et al.*, 2006). Ammonia emission is reduced with regular litter change, use of appropriate litter material, decreased manure moisture and improved indoor conditions (Meda *et al.*, 2011).

LITTER AMENDMENTS

Poultry litter amendments to effectively control ammonia levels involves application of acidifiers, alkaline materials, adsobers, inhibitors, microbial and enzymatic treatments, superabsorbent polymers and even dietary manipulations (Blake, 2001; Sanjay *et al.*, 2006; Meda *et al.*, 2011; Timmons and Harter-Dennis, 2011).

Acidifiers such as alum, sodium bisulphate, ferrous sulphate and phosphoric acid are the most effective and widely used poultry litter amendment and work by creating acidic conditions in litter so that ammonium rather than ammonia is retained and this helps facilitate bacteria and enzyme inactivity so that ammonia is not produced in the litter (Sanjay *et al.*, 2006; Moore *et al.*, 1996). Alum reduced NH_3 by 71-92% while phosphoric acids by 56-92% (Moore *et al.*, 1996). They suppress ammonia levels below 25 ppm for 3-4 weeks post application and improve in-house air quality in poultry houses (Sanjay *et al.*, 2006).

Alkaline materials like agricultural lime ($CaCO_3$), hydrated or slaked lime ($Ca(OH)_2$), or burnt lime (CaO) work by increasing litter alkalinity (pH>7) which help to convert more of the ammonium within litter to gaseous ammonia that can be readily lost through venting so that lower ammonia level is achieved when next batch of chicks are brought. However, this practice is associated with loss of soluble phosphorus level in litter with low fertilizer value and may have negative impact on the environment as ammonia levels may later increase significantly when fresh manure is added to the litter (Sanjay *et al.*, 2006).

Adsobers like certain natural clay type (zeolite) and peat are good in adsorbing ammonia and lowering ammonia levels if used in poultry houses (Sanjay *et al.*, 2006). Inhibitors in poultry litter slowly convert uric acid and urea to ammonia by the process of inhibiting enzymes and microbial activities. In the recent past, phenyl phosphorodiamidate was reported to inhibit urease activity and reducing conversion of urea in to ammonia (Sanjay *et al.*, 2006).

Microbial and enzymatic treatment of litter uses beneficial microbes and enzymes which can convert uric acid and urea fairly rapidly in to ammonia which can then be vented out thereby reducing the ammonia levels before chicks are placed in the house later. Such microbial products like USM-98 or *Yucca schidigera* extract as a natural feed additive were reported to significantly lower ammonia levels, improve bird weights and reduced mortality (Sanjay *et al.*, 2006).

Dietary manipulation involves reducing the nitrogen intake per bird by reducing the crude protein in poultry diet, because ammonia is formed by the breakdown of undigested protein and uric acid in the manure (Meda *et al.*, 2011). A 1% reduction of CP resulted to 10-22% reduced NH_3 emission (Meda *et al.*, 2011).

Increased age and weight at slaughter will influence NH_3 emissions because nitrogen excretion per day per bird increases with increasing daily feed intake (Amanullah *et al.*, 2010).

POULTRY WASTE PROCESSING AND UTILISATION

Poultry waste materials including litter and dead birds must be properly managed to ensure beneficial use and to prevent adverse effects on the environment and poultry health. Litter should not be reused when a disease outbreak occurs in a flock (Anne, 2007). Effective management of poultry wastes incurs expenses not normally recognized in production budgets, such wastes may be valuable by-products or strictly a net cost. In some advanced countries, poultry farmers register their operations with appropriate agencies, keep records of poultry wastes and develop an approved animal waste management plan. In the developing countries this is not the situation and therefore environmental pollution and disease spread is rampant. Below are some practical activities that may render poultry waste easily manageable and ensure environmental safety.

Converting poultry litter into bio-fuel: Efforts towards safe disposal of poultry wastes resulted in to a recent technology that converted poultry litter to valuable bio-oil, usable gas and crop fertilizers (Anonymous, 2007). Broiler and turkey litters were converted into bio-oils and fertilizer while the gas generated was used to operate pyrolysis unit in a self-sufficient machine (Anonymous, 2007). The thermochemical unit in this system succeeded in destroying the pathogenic microorganisms and reduced the chances of disease transmission (Anonymous, 2007). There are currently several electrical generating plants in the UK and recently in the US that are utilizing poultry and turkey litter as their primary fuel (Anonymous, 2007).

Composting of poultry litter: Composting of poultry litter and dead carcasses is an option to be considered to increase value and market for poultry litter readily needed in forestry, crop and vegetable farms, homes, lawns and golf courses (Forbes, 2006). Composting is a simple natural biological phenomenon that renders poultry litter odourless, stable, consistent and soil-like that is unable to damage crops and surface waters. It is a controlled decomposing natural breakdown process of organic materials (Anne, 2007). The process utilizes aerobic microorganisms in the poultry litter in the presence of oxygen and water to change the chemical and physical nature of poultry litter to form a humus-like material referred o as compost (Forbes, 2006). Composting reduces litter weight to as much as 40-80% (Anne, 2007) and compost has been reported to air condition soils and improve soil quality by adding organic matter, nutrients and beneficial microbes thereby increasing soil porosity, density, water and nutrient holding capacity (Forbes, 2006). It is important to note that the major nutrients of poultry litter include carbon, nitrogen, phosphorus, potassium and others needed for plant and microorganisms growth and reproduction (Embury, 2004), it is referred to as an excellent soil amendment (Anne, 2007). Composted broiler litter for instance has a pH of 5.5-6.5 and is weed free making it suitable fertilizer for seedlings, shrubs, roses and fruit tries and is rich in vitamin B12 (Embury, 2004; Anne, 2007).

Storage of poultry litter: The demand for poultry litter like some other seasonally demanding goods appears to be sporadic and therefore requiring temporary holding until an appropriate application time even though fresh poultry litter has the highest nitrogen content making it of greater fertilizer value (Embury, 2004). Proper storage of poultry litter will ensure the most benefit use of valuable fertilizer nutrients and will prevent contamination of surface waters on poultry farms (Dan *et al.*, 2009). The most valuable nitrogen in poultry litter is gradually lost to the atmosphere as ammonium over a prolonged period (Doye *et al.*, 2009). Covered stockpiles; involves stockpiles of litter that is covered using plastic sheets anchored to the earth or other devices to protect against rain and atmospheric losses. Stockpiles with ground liners; this involves the use of good plastic as liner to ground or concrete slabs to primarily prevent nutrient leaching to ground water (Dan *et al*., 2009). Permanent storage structures with sufficient roofs and concrete floors appear to be best but associated with high risk of spontaneous combustion and fire outbreaks (Dan *et al*., 2009).

Applying poultry litter to crops: Certain considerations are put in place before litter can be effectively and safely applied on farms (Dan *et al*., 2009). Poultry manure should not be applied to very steep lands, lands in close proximity to surface waters, drainage ditches and wells. Avoid application prior to heavy rains and to crops best apply at the time of nutrient needs. Litter should generally be applied to as close to planting time as possible and should be mechanically incorporated to plants as soon as possible after application (Forbes, 2006). This approach will minimize loss due to ammonia volatilization and nutrient loss by wind and water erosion. Application of litter well ahead of planting will lead to denitrification and leaching (Forbes, 2006). A trial of bioactive compost on crops indicated that compost containing poultry litter gave plant maximum levels of nutrients required, growth promoting effects and cost benefit (Kavitha and Subramanian, 2007).

Poultry litter as ruminant feed supplement: Poultry litter has traditionally being used efficiently as a fertilizer; it is now also used as a cost-saving livestock feed supplement for ruminants especially cattle, goats and sheep (Murthy *et al*., 1995; Anonymous, 2006; Adegbola *et al*., 2010; Nwaigwe *et al*., 2011). It is high in urea, a source of nitrogen, which improves the rumen environment making feed more efficiently utilized and the animal better nourished with whatever feed that is made available (Murthy *et al*., 1995; Adegbola *et al*., 2010). Uric acid which is a major content of poultry waste can be utilized by rumen microbes for protein production as it is not easily dissolved in the rumen fluid and the ammonia is only slowly released making it more efficiently utilized than other non-protein nitrogenous sources (Abdel-Baset and Abbas, 2010). Composted litter is reach in B vitamins especially B12 (Anne, 2007). Ordinarily, the rumen micro flora seems to take about 3 weeks to adapt before it can fully utilize uric acid therefore do not give the manure mixture to young cattle less than 5 months old, or to sheep and goats less than 3 months old (Murthy *et al*., 1995). When processed by an acceptable method, poultry litter is a very economical and safe source of protein, minerals and energy for many classes of ruminants (Murthy *et al*., 1995; Abdel-Baset and Abbas, 2010; Adegbola *et al*., 2010). Also, it has a total digestible nutrients value similar to average quality hay and can provide a major portion of the energy to maintain ruminant if it is readily consumed (Abdel-Baset and Abbas, 2010). However, poultry manure has been reported to be best economically used in the ruminant feeding as a forage substitute during drought and when there is forage shortage. The poultry litter contains high fibre and ash and so are the rations formulated containing poultry litter generally attributed to excretion of minerals in the litter (Chauhan, 1993; Anonymous, 2006).

At higher levels, poultry litter in ruminants depressed growth rate because dried poultry litter is low in the essential amino acid needed by animal and also because of excessive amount of calcium the litter contains (Abdel-Baset and Abbas, 2010). In another development, it was shown that poultry manure can replace groundnut cake in the diet of goats without any depression in growth rate and efficiency of feed utilization when used with a good source of carbohydrates such as cassava peel (Adegbola *et al*., 2010). Digestibility of crude fiber was also reported to be higher in rations containing poultry litter and that incorporating poultry litter up to 25% in the rations of camels did not have any adverse effects (Abdel-Baset and Abbas, 2010) and that poultry droppings could effectively substitute cotton seed cake in the diets of suckler cattle (Bayemi *et al.*, 2001) and was found to improve daily weight gain in growing cattle (Mubi *et al.*, 2008). Similarly, Khattab *et al.* (1995) and Gabr *et al.* (2003) were able to demonstrate such with buffalo calves and sheep respectively. Unfortunately, poultry manure can carry pathogenic organisms that can cause disease in other animals if the manure is not sun-dried well enough (Adene, 1997). Furthermore, wood shavings as the commonest litter materials in Nigeria are usually obtained from wood work industries that may contain sharp or metallic objects which have caused traumatic ventriculitis in poultry traumatic pericarditis in ruminants (Musa *et al.*, 2009; Musa *et al.*, 2011). A research concluded that poultry waste intended to be used in compounding rations for cattle should be dried or ensiled and screened for metallic objects to render it safe for use by the animals (Abdul *et al.*, 2008; Musa *et al.*, 2011). Ensiling sorghum forage or molasses with poultry waste had improved crude protein content of the silage almost twofold. Rations formulated with 30% of the concentrate as poultry waste gave about 10 kg of milk/day (Odhuba, 2006; Owen *et al.*, 2008b).

However, wet poultry manure should not be fed to livestock and the optimum supplement level for dairy cows is 1 to 2 kg daily (Abdul *et al.*, 2008).

Poultry litter as fish and rabbit feed supplement: Nigeria is reported to be the largest importer of frozen fish in the world (Solarin, 1992). Aquaculture integration with livestock particularly poultry has been on the increase in Nigeria in recent years with a major limitation of formulated fish feed. Research works have been conducted to determine the effectiveness of feeding cow, pig and poultry manure in variety of fish species (Campos and Sampao, 1976; Anonymous, 2006). Chickens because of their short intestines are capable of excreting about 20% undigested feed and that 10% of feed fed to chickens are wasted to the litter in the process of feeding making available 10-30% total protein content of dry chicken waste, 1100-1400 kcal kg^{-1} energy and soluble synthesized vitamins in abundance in the poultry manure (Tuleun, 1992; Anonymous, 2006). Some farmers while taking this advantage have constructed battery cages directly on ponds while others continue to feed fish poultry manure (Rangayya, 1977) so that waste is now recycled in to inputs. The nitrogenous waste from birds can also efficiently fertilize ponds for growth of plankton as fish food (Adewumi *et al.*, 2011). In fact a report from the United States indicated no difference in terms of growth rate of tilapia cultured in manured ponds compared to fish fed pelleted commercial feed (Collins and Smitherman, 1978). However, use of poultry litter in *Clarias* species as sole feed was reported to have adverse metabolic effects (Omitoyin, 2007). The use of poultry litter as supplement was reported to have added advantage over routinely used protein sources in rabbit diet (Owen *et al.*, 2008a).

CONCLUSIONS

Economic losses as a result of poor litter and poor litter management are significantly high. Litter type and management are dependent upon cost, availability and quality of materials used. Therefore, materials intended to be used as litter material should meet the criteria for selection. Research is needed to determine the exact need and rate of poultry litter application to plants and animals. Poultry waste should best be fed to ruminants after ensiling and following careful considerations, should not be utilized where BSE has been reported. The basic technology of feed compounding using poultry manure can be developed and transferred to farmers.

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