

## CHAPTER 1

### 1.0 REVIEW OF LITERATURE

#### 1.1 GENERAL INTRODUCTION

In the 1950's, poultry waste emerged in the USA as an alternate source of nitrogen in ruminant nutrition (Fontenot, 1991). The product has been classified into two main types because of their distinct differences in composition: broiler litter, consisting of the excreta (urine and faeces) from broilers kept on deep litter systems with “bedding” material, and pure poultry excreta from layers housed in battery cages (dried caged poultry waste)(Fontenot & Jurubescu, 1980). Broiler litter differs in composition from layer manure mainly because of the differences in diets fed and the bedding material that is mixed with the broiler excreta.

The dramatic growth of the poultry industry over the last 40 years created a serious waste disposal problem. The utilisation of the waste through ruminant animals became a convenient option of disposing of the waste. The product is readily accepted by the cattle and sheep farmer, not because of any superior feeding qualities, but simply because it is cheaply available.

The feeding of poultry waste prompted active research in the USA on the use of the product. Aspects such as its nutritive value, its effect on the health of the animal and the human and suitable methods of processing the waste have been investigated (Belasco, 1954; Brugman *et al.*, 1954; Ammerman *et al.*, 1966; Bhattacharya & Fontenot, 1966;

Bhattacharya & Taylor, 1975; Smith *et al.*, 1978). Guidelines have been compiled on the use of poultry waste as a ruminant feed (Fontenot, 1991; Carter & Poore, 1998; Crickenberger & Goode 1998). Presently, the main thrust in research in the USA seems to be on methods of processing and storing of the product and effects there-of on nutritive value (Carter & Poore, 1998; Kwak *et al.*, 1998).

World wide, research has been conducted on the use of poultry excreta as an animal feed, e.g. in the 1990's research continued in Africa (Manyuchi *et al.*, 1992; Ngongoni & Manyuchi, 1993) and in the Middle East (Deshck *et al.*, 1998; Brosh *et al.*, 1998).

In South Africa the first report of cattle fed poultry manure, appeared in a farmer's magazine in 1960 (Anonymous, 1960). In the 1970's results of a number of investigations on the feeding and use of the product have been reported (Bishop *et al.*, 1971; Van der Westhuizen & Hugo, 1972; Bosman, 1973; Van der Merwe *et al.*, 1975; Van Ryssen *et al.*, 1977; Kargaard & Van Niekerk, 1978). In 1980 legislation was introduced to control the feeding of the product in South Africa (Act 36 of 1947), stipulating that poultry waste products may only be sold as a livestock feed if the specific product is registered with the Registrar of Feeds as an animal feed, complying to specific nutritional and hygienic standards (Government Gazette, 1980). Despite that, unregistered poultry waste was and is still used extensively by farmers, both as a winter supplement and as an ingredient in feedlot rations (Kitching, 1986; Van Ryssen, 1988). This resulted in strong opposition to the feeding of the product because of major health concerns, and also from private feed companies whose turn-over in sales of protein supplements was affected detrimentally

(Kitching, 1986; Van Ryssen, 1988). Probably because of this, since 1980 research in South Africa focused mainly on possible harmful effects of poultry manure as a livestock feed (Ogonowski *et al.*, 1984; Nel, 1989; Fourie *et al.*, 1991; Van Ryssen, 1991; Van Ryssen *et al.*, 1993; Bastianello *et al.*, 1995).

## **1.2. COMPOSITION OF POULTRY WASTE**

Poultry waste, in general, is classified as a bulky protein supplement (Kitching, 1986). The product is of an alkaline nature with a positive cation-anion balance (Pugh *et al.*, 1994), resulting in a high buffering capacity in the rumen of animals.

### **1.2.1 Crude protein**

Relatively high crude protein (nitrogen X 6.25) concentrations of up to and over 300 g/kg dry matter (DM) have been reported (Bull & Reid, 1971; Flegal & Zindel, 1970; Hodgetts, 1971; Polin *et al.*, 1971; Fontenot & Jurubescu, 1980). The crude protein consists of both true protein nitrogen and non-protein nitrogen, with uric acid the main non-protein nitrogen constituent in poultry wastes (Noland, 1955; Ruffin & McCaskey, 1998). In manure containing 68 g/kg nitrogen, 26 to 34 g/kg units consisted of uric acid and 21 g/kg units of amino acid nitrogen (Smith *et al.*, 1978). Other non-protein nitrogen components in manure include ammonia, urea and creatinine (Fontenot & Webb, 1974). Caged layer manure analysed by Fontenot & Webb (1974) contained 41 g amino acids /kg DM and 59 g non-protein nitrogen /kg DM. The total nitrogen in poultry waste analysed by Jakhmola *et al.* (1988) contained 49 to 60 g/kg, and that of Ruffin & McCaskey (1998) over 40 g/kg non-protein nitrogen. Bhattacharya & Fontenot (1966) observed that the

true protein in peanut hull and wood-shaving broiler litter is high in glycine and somewhat low in arginine, lysine, methionine and cystine compared to lucerne hay.

### 1.2.2 Ash and minerals

Broiler litter is not only recognised as a crude protein supplement, but also as a mineral source for beef cattle (Doctorian & Evers, 1998).

Differences in ash content between layer and broiler wastes is to be expected because of the difference in composition of the feed fed to the two classes of birds (Benne, 1970). According to Deshck *et al.* (1998) the total ash concentration of layer manure is approximately twice as high as that in broiler litter. Dehydrated cage layer waste contained 280 g ash /kg DM (Benne, 1970). Brugman *et al.* (1964), Bhattacharya & Fontenot (1966) and Fontenot *et al.* (1971) reported ash concentrations in broiler litter of approximately 150 g/kg DM versus 280 g/kg in dry layer waste. In South African samples Van Ryssen *et al.* (1993) measured an average ash concentration in dried broiler litter of 137 g/kg versus 350 g/kg DM in layer manure. Silva *et al.* (1976) cited an ash content of 600 g/kg in dried poultry waste, but attributed this high concentration to the charring of the product during drying.

Ash in layer manure consists largely of calcium and phosphorus, constituting 88 and 25 g/kg DM respectively (Long *et al.*, 1969; Flegal & Zindel, 1970; Hodgetts, 1971; Polin *et al.*, 1971). Similarly, South African layer manure samples contained 88 g calcium and 23 g phosphorus /kg DM (Van Ryssen *et al.*, 1993). Fontenot & Jurubescu (1980) and Van

Ryssen *et al.* (1993) measured calcium and phosphorus concentrations in broiler litter of 24 and 18, and 25 and 15 g/kg DM, respectively. According to a report by Fontenot & Jurubescu (1980) dehydrated cage layer waste contained 6.7 g magnesium, 9.4 g sodium, 23.3 g potassium, 150 mg copper, 406 mg manganese and 463 mg zinc /kg DM. In the same report broiler litter contained 4.4 g magnesium, 5.4 g sodium, 17.8 g potassium, 451 mg iron, 98 mg copper, 225 mg manganese and 235 mg zinc /kg DM. Westing *et al.* (1985) measured mineral concentrations of broiler litter of 37 g calcium, 6.3 g magnesium, 37 g potassium, 6.6 g sodium, 1023 mg iron, 593 mg copper, 271 mg manganese and 496 mg zinc /kg DM.

### **1.2.3 Available energy**

Bhattacharya & Fontenot (1966) reported a digestible energy value of broiler litter of 10.21 MJ /kg DM for sheep, that of dehydrated layer waste 8.00 MJ /kg DM and that of Lucerne hay 10.37 MJ / kg DM. Bhattacharya & Taylor (1975) cited dehydrated layer manure samples containing a digestible energy concentration of 8.37 MJ /kg DM for sheep and cattle. A digestible energy value of layer manure for cattle was found to be 7.85 MJ /kg DM (Bull & Reid, 1971) and for sheep 8.00 MJ /kg DM with a total digestible nutrient (TDN) value of 573 g/kg (Tinnimit *et al.*, 1972). Bhattacharya & Fontenot (1966) also measure a metabolisable energy value of 9.13 MJ /kg broiler litter, which did not change when bedding material was changed from wood shavings to peanut hulls. However, when citrus pulp was used as bedding material, the digestible and metabolisable energy values increased (Malik & Bhattacharya, 1971).

#### **1.2.4 Fat and fibre**

Studies by Long *et al.* (1969), Bull & Reid (1971), Flegal & Zindel (1971) and Hodgetts (1971) reported low fat (20 g/kg) and relatively high crude fibre (127 g/kg) concentrations in dried layer waste. Similarly, broiler litter contained 33 g fat and 168 g crude fibre /kg DM (Brugman *et al.*, 1964; Bhattacharya & Fontenot, 1966; Fontenot *et al.*, 1971).

#### **1.2.5 Vitamins**

The literature is silent on vitamin content of broiler litter.

### **1.3 ANIMAL PERFORMANCE**

Poultry litter has been successfully used as a protein supplement for gestating-lactating ewes (Noland *et al.*, 1955; Fontenot *et al.*, 1971), wintering cattle (Fontenot *et al.*, 1964), growing lambs (Galmez *et al.*, 1970) and fattening cattle (Southwell *et al.*, 1958; Drake *et al.*, 1965; Harmon *et al.*, 1975; Cullison *et al.*, 1976). Cullison *et al.* (1976) reported no differences in the performance of steers receiving dried broiler excreta as 0, 50 and 100 percent of their supplemental protein. The daily weight gains were observed as 1.20, 1.18 and 1.11 kg, respectively, for 0, 50 and 100 percent dried broiler litter diets. Chester-Jones *et al.* (1972) observed that cattle fed diets of corn silage supplemented with soybean meal, deep-stacked or ensiled broiler litter, gained 1.09, 1.07 and 1.01 kg/day, respectively. In another study, cattle were fed a hay concentrate based diet with 0, 20, 40 and 60 percent ensiled or deep-stacked litter (dry bases). The incorporation of 60 percent litter decreased dry matter intake below that of the control. The average daily gains of the cattle on the 20 percent deep-stacked litter (1.03 kg) or 20 percent ensiled litter (0.92 kg)

were higher than for those on the control (0.94 kg). Cattle fed 40 percent ensiled litter in their diet had similar gains to the 0 percent litter control (0.92 kg). Gains were lowest for steers fed the 60 percent level of deep-stacked (0.58 kg) and ensiled (0.55 kg) litter compared to the control. Feed conversion efficiency was similar for the control, 20 and 40 percent litter diets, however, decreased markedly at the 60 percent level.

#### **1.4. POTENTIAL PROBLEMS AND RISKS OF FEEDING POULTRY WASTES**

Bishop *et al.* (1971) described the using of poultry manure as a supplement and as a complete feed for sheep in South Africa. Forced by drought and total lack of edible roughage, one farmer fed 2000 sheep molasses-moistened laying-hen manure as their total diet. After one month the ewes that were close to lambing developed a lameness of the limbs and could not move about. The farmer lost 50 sheep. Some ewes that developed abnormalities, recovered when the proportion of litter in the diet was reduced to 400 kg manure in a diet with 400 kg sawdust, 180 kg maize meal and 56 kg molasses.

Within 8 weeks of feeding diets containing from 45 to 60 percent dried battery waste to weaning lambs (Angus *et al.*, 1978) lower feed intakes were reported, with concomitant hypoalbuminaemia, ascites, centrilobular necrosis and fibrosis of the liver. They also found that the feeding of high levels of broiler litter caused damage of renal tubular epithelial cells in the lambs. This could not be explained but was suggested to be due to lowered resistance because of kidney infection.

These serve as examples that problems can be anticipated in the animal consuming the poultry waste. However, the user should be aware also of health risk to humans consuming the products from animals fed the poultry waste. In the present investigation the effect of including high levels of broiler litter in sheep diets, were studied. Any problems associated with the feeding of litter would be accentuated under such conditions. Therefore, a review of the literature regarding risks and health aspect in the feeding of poultry excreta has been conducted. Potential problems are related to nutrition, and the transfer of diseases, drug and drug residues between the product and the animal.

#### **1.4.1 Nutritional**

##### **Variation in composition**

Poultry waste is a variable product which does not have a constant composition and feed value (Oosthuizen, 1979). The variation in composition complicates the formulation of rations with the product. Therefore, the product must be analysed to ascertain its chemical composition, especially the crude protein and ash concentrations, before it can be used in formulating animal rations (Brosh *et al.*, 1998).

Differences in composition of broiler litter will be affected by the duration of storage, age and strain of birds and the diets fed to the birds (Shuller, 1976). Furthermore, the composition of broiler litter will vary with different sources of bedding which may include maize cobs, peanut hulls, rice hulls, wood shavings, soybean hulls and straw (Ammerman *et al.*, 1966). Other bedding materials include sunflower husks and mature veld hay (Ngongoni & Manyuchi, 1993). The proportion of bedding material in the



manure has an influence on the composition of the final product which depends on the amount used, the density of birds on the floor and the duration of their stay in the houses (Van Ryssen *et al.*, 1977; Goetsch *et al.*, 1998 ). In South Africa the standard practice is to remove the litter from the houses after each batch of broilers. The method of processing will influence the composition of the litter (Jakhmola *et al.*, 1988).

An analysis of samples from various parts of South Africa indicated crude protein concentrations ranging from 100 to 300 g/kg, ash from 150 to 580 g/kg, moisture from 80 to 240 g/kg, phosphorus from 9 to 20 g/kg and potassium from 6 to 20 g/kg DM (Oosthuizen, 1979).

### **Moisture content**

Fresh droppings from caged layers can contain up to 700 g moisture/kg DM, while well dried and cured manure will contain less than 100 g moisture/kg DM (Oosthuizen, 1979). Kitching (1986) reported 60 to 240 g/kg moisture in broiler litter. Factors affecting the moisture content include climate, ventilation in houses, diet of birds, condition of storage, processing and drying practice. A high moisture content causes not only problems with storage and transport of the product, but creates an ideal medium for pathogens to grow in. This is discussed in a later section.

### **Bulkiness and transport**

Poultry litter is a bulky product and its transportation may be expensive when considered per unit nutrients. Bulkiness depends on moisture content and proportion and kind of

bedding material present. At a 70 percent moisture the volume of manure is 1 M<sup>3</sup>/ton while with 20 percent moisture it is 2 to 2.5 M<sup>3</sup>/ton (Van Ryssen, unpublished).

### **Crude protein**

Poultry litter is a good source of non-protein nitrogen for ruminants (Smith & Calvert, 1976; Caswell *et al.*, 1978; Smith *et al.*, 1979), but according to Fontenot (1971) does not contain enough available energy for the rumen micro-organisms to utilise the nitrogen. Oltjen *et al.* (1968) observed that uric acid is broken down in the rumen at a slower rate compared to urea and consequently most of the ammonia is intercepted by the rumen micro-organisms, thus reducing the risk of ammonia toxicity of the ruminant. At high intakes of litter, high concentrations of ammonia will occur in the rumen. A proportion of the ammonia, depending on the rumen pH, would be absorbed through the rumen wall and be processed in the liver to urea (Symonds *et al.*, 1981). Silanikove & Tiomkin (1992) observed liver damage in cows fed poultry manure as the sole overwintering diet and attributed this to the high ammonia concentrations in the rumen due to non-protein nitrogen catabolism. However, Rossi *et al.* (1998) suggested that the liver damage observed by Silanikove & Tiomkins (1992) could have been due to copper toxicity.

Jordan & Swanson (1979) observed an increase in days from calving to conception and in number of services per conception in dairy cows with increasing concentrations of crude protein in the diets. They insinuated that the high plasma urea and ammonia concentrations increased the pH in the reproductive tract and thus reduced the motility and survival of sperm. Polman *et al.* (1981) confirmed these observations on reproductive

performance and speculated that production of ammonia or other substances in the rumen may reduce fertility by lowering plasma progesterone. Erb *et al.* (1976) reported reduced reproductive performance when dairy cows consumed 450 g/day urea and their data implicated ammonia. The above experiments may imply that if the feeding of broiler litter to cows result in elevated rumen and blood ammonia concentrations, it may have negative effects on fertility in cows. Also, the elevated rumen and blood ammonia concentrations may represent a drain on energy required to catabolize the ammonia .

### **Minerals**

An abundance of most minerals is present in poultry excreta (Westing *et al.*, 1985) and it is an excellent source of minerals to the animal (Ruffin & McCaskey, 1990). Van Ryssen *et al.* (1993) concluded that "relatively high even toxic levels of some minerals can be present in manure" when they analysed poultry manure from South African sources. Since many of the toxic symptoms of minerals are induced deficiencies of other minerals, Van Ryssen *et al.* (1993) suggested that such deficiencies may not necessarily occur when poultry excreta is fed because of the high concentration of most minerals in the product.

### **Calcium and phosphorus**

The calcium concentration of the South African broiler litter was 25 g/kg and in layer manure 88 g/kg and that of phosphorus 15 and 23 g/kg DM, respectively (Van Ryssen *et al.*, 1993). These calcium and phosphorus concentrations are well above the requirements of beef cattle and sheep (NRC, 1980; Ruffin & McCaskey, 1990). Ruffin & McCaskey (1990) indicated that, if brood cows are fed an 80 percent litter and 20 percent grain diet,

they will consume five times more calcium, phosphorus and potassium than required. The problem typically associated with high dietary calcium concentrations is milk fever (parturient paresis) which has been observed in beef cows at parturition (Kitching, 1986; Silanikove & Tiomkin, 1992; Pugh *et al.*, 1994; Rude & Rankins, 1997). Combined with the hypocalcaemia in cows on high litter diets, hyperphosphataemia was observed as well (Silanikove & Tiomkins, 1992; Rankins *et al.*, 1993). Feeding of broiler litter to pregnant cows has been shown to suppress serum calcium concentration even though calcium retention in the body of cows was increased (Muirhead, 1996; Rude & Rankins, 1997). The suppression of serum calcium concentration is as a result of continued deposition of calcium in the bones even at a time when the demand for it in milk synthesis was high (Muirhead, 1996). Feeding of hay together with broiler litter diets was found to minimise this potential problem (Muirhead, 1996).

### **Copper**

Copper sulphate is included in broiler diets at a level of approximately 150 mg copper/kg feed to act as a growth promotant and fungicide (Fisher *et al.*, 1972; Vest & Dyer, 1993). Consequently, the excreta of these birds contains high concentrations of copper (Rankins *et al.*, 1993; Vest & Dyer, 1993) which could induce copper toxicosis in ruminants consuming the excreta. Fontenot *et al.* (1971) and Webb *et al.* (1973) reported cases of copper toxicity in sheep consuming diets high in poultry manure. In response to a problem of copper toxicity among sheep consuming poultry manure, Van Ryssen *et al.* (1977) conducted a survey of the mineral concentration of poultry manure samples in South Africa. They measured copper concentrations of up to 570 mg /kg DM in broiler

litter samples, but averages of 36 and 47 mg/kg DM in pure battery manure and in litter from pullets and broiler breeders on deep litter systems respectively. In a more comprehensive survey conducted in the early 1990's, Van Ryssen *et al.* (1993) observed that none of the litter samples contained high concentrations of copper. They concluded that the feed manufacturers in South Africa apparently discontinued the inclusion of copper sulphate in their poultry diets.

Legislation in South Africa stipulates that both broiler litter and layer excreta shall not contain more than 50 mg copper/kg, if it is to be registered as an animal feedstuff (Government Gazette, 1980). Even within these legal limits, the copper concentration in broiler litter is vastly above the copper requirements of sheep (NRC, 1985), the species of farm animals most susceptible to copper toxicosis. However, Van Ryssen & Jagoe (1982) found no increase in copper accumulation in the livers of sheep receiving rations containing up to 36 percent litter with a copper concentration of 17.8 percent in the final ration. They concluded that many of the antagonists to copper metabolism in the ruminant, such as zinc, iron, sulphur and molybdenum plus sulphur are usually present at high concentrations in litter and would reduce the availability of copper in the product. Furthermore, most of the sheep breeds (the Merino types) in South Africa are quite resistant to copper toxicosis compared to breeds in the United Kingdom and Europe (Harrison *et al.*, 1987). In contrast to the situation in South Africa, it seems as if copper sulphate is included extensively in poultry diets in the USA. Broiler litter collected in the State of Alabama, USA had an average copper concentration of 473 mg/kg, ranging from 25 to 1003 mg/kg (Ruffin & McCaskey, 1998). Westing *et al.* (1985) recorded a copper

concentration in broiler litter of 593, Vest & Dyer (1993) a concentration of 558 and Olson *et al.* (1984) a concentration of 257 mg/kg DM. At concentrations of between 262 and 272 mg copper /kg broiler litter, Rankins *et al.* (1993) observed a linear increase in the liver copper concentration of steers with the increasing addition of dietary broiler litter, though observed no signs of toxicity among the cattle. In cattle the high copper intake through litter is usually not a problem (Fontenot, 1991). However, Banton, *et al.* (1987) reported cases of copper toxicosis in cattle fed chicken litter containing 620 mg copper/kg DM. It can be concluded that, presently, copper toxicosis due to the consumption of broiler litter by sheep should not be a serious problem in South Africa.

### **Arsenic**

Arsenicals are used for the treatment of specific diseases but when used at low levels may have growth promoting properties (Calvert, 1971). Drugs and growth promotants containing arsenic such as arsanilic acid or sodium arsanilate, arsenobenzene, 3-nitro-4-hydroxyphenylarsonic acid and 4-nitrophenylarsonic acid are included sometimes in broiler diets (Calvert, 1971). This can result in the excretion of arsenic residues in the manure (Calvert, 1974). Except for manure samples from free-range poultry, Van Ryssen *et al.* (1993) did not measure high arsenic concentrations in poultry excreta collected in South Africa. The average concentration for the South African samples was 4.9 mg/kg DM. Westing *et al.* (1985) reported a concentration of 76 mg arsenic /kg DM in broiler litter.

Feeding of arsenical has been reported to increase liver arsenic concentration in cattle. However, the levels were lower than the accepted minimum safe levels (Webb & Fontenot, 1975). Calvert (1973) observed that most of the arsenic was excreted by sheep with minimal retention in the body when 14 percent chicken manure containing 42 mg/kg arsenic was included in a sheep ration. Calvert & Smith (1972) observed no increase of arsenic in milk from cows consuming 40 mg arsenic per cow per day through the consumption of broiler manure. No detectable arsenic could be found in the liver, heart, spleen, 12th rib, kidney, kidney fat or brain tissue of lambs fed poultry litter supplemented with 3-nitro-4-hydroxyphenylarsonic acid ( Brugman *et al.*, 1968). Arsenic in drinking water (5 ppm) prevents selenium toxicity (Lloyd *et al.*, 1978).

### **Selenium**

Relatively high concentrations of selenium have been recorded in poultry manure. In the South African sources Van Ryssen *et al.* (1993) reported concentrations of 0.62 and 0.24; 0.47 and 0.25; 0.42 and 0.22 mg selenium /kg DM in broiler litter, pure laying hen manure and pullet litter, respectively. Similarly, high concentrations were measured elsewhere, e.g. 1.09 mg selenium (Westing *et al.*, 1985) and 0.95 mg selenium (Ben-Ghedalia *et al.*, 1996) /kg dry poultry litter. However, it is claimed that selenium in animal excreta is relatively unavailable to plants and animals (Allaway, 1973; Stowe & Herdt, 1992; Ullrey, 1992). Whether this is true for the selenium in poultry excreta, has not been established.

## **Iron**

Broiler litter has been reported to contain 1335 mg iron /kg DM (Van Ryssen, 1993). Similar iron concentrations were reported by other researchers (Essig, 1975; Westing *et al.*, 1985, Ruffin & McCaskey, 1990). Van Ryssen *et al.* (1993) pointed out that the level of iron in the survey samples was well above the requirement of the ruminant. Although iron is necessary in biological systems, it is a potent oxidant or pro-oxidant that can adversely affect cell function (Pitzen, 1994). Pitzen (1994) concluded that the rancid off-flavour observed in milk from cows was as a result of high iron intake. Cows on a high iron diet tended exhibit silent heat, soar feet and uterine infection (Pitzen, 1994). Furthermore, Valdivia *et al.* (1982) indicated the main toxic effect of iron and aluminium to be induced deficiencies of other minerals.

## **Ash content**

According to Brosh *et al.* (1998) the commercial value of poultry litter is based on its crude protein and ash content. Ash is diluting the concentration of other nutrients in broiler litter. Broiler litter high in ash content has the possibility of a notable amount of litter remaining in the rumen by settling to the bottom (Brosh *et al.*, 1998). It has been suggested that a high quantity of ash rich organic matter complex would probably sink to the bottom of the rumen thus interfere with normal rumen motility and the movement of particles to the rumen omasum orifice (Brosh *et al.*, 1998). Consequently, rumen particulate emptying and dry matter intake would be reduced and mean retention time (MRT) extended (Brosh *et al.*, 1998). The main factor that limits intake of a high ash diet



is the ability to mobilise and dispose of the complex. No serious health problems have been attributed to high ash content in diets for livestock.

#### **1.4.2 Gastro-intestinal impaction**

##### **Problem of bloat**

The physical and chemical nature of broiler litter, e.g. small particle size, high solubility and high density of insolubles is conducive to lack of ruminal stimulation with a low saliva flow and a low voluntary intake (Patil *et al.*, 1995; Rossi *et al.*, 1996). A consequence of this is the occurrence of bloat in cattle on high litter diets (Ruffin & McCaskey, 1998). A standard recommendation in the USA is that long hay must be supplied when cattle are fed diets high in broiler litter (Fontenot, 1991; Ruffin & McCaskey, 1998).

#### **1.4.3 Transmitting of drug residues**

Fontenot & Webb (1975) and McCaskey & Anthony (1979) have reviewed the health aspects of feeding poultry wastes or animal wastes and regulatory considerations in the use of animal wastes as feedstuffs. Poultry waste, just like any other animal feedstuff, is a potential source of bacteria, fungi, viruses, parasites and chemical residues (mycotoxins, pesticides, hormones, toxic minerals and medicinal drugs). Thus, precautions when utilisation of poultry wastes as feedstuffs should be taken to eliminate the potential health problems that may result from using poultry wastes as feedstuff.

## **Parasites**

Internal parasites are not transmitted from poultry to ruminants (Wuethrich, 1978). They can be transmitted from poultry to poultry if unprocessed manure is included in poultry diets. Kitching (1986) mentioned a case where the carcasses of cattle that received broiler litter were infested with measles. It turned out that the litter was contaminated with human excreta because farm labourers used the poultry house as a toilet.

## **Fungi, bacteria, pathogens and toxins**

Poultry litter is an ideal medium for the development of fungi. Lovett *et al.* (1971) reported 17 different types of fungi in poultry litter from commercial poultry enterprises. The most abundant of these fungi included *penicillium*, *aspergillus*, *scopulariopsis* and *candida*. Mycotoxins produced by *Aspergillus* species are most likely to be a problem, especially if the litter fed to animals is damp. Presence of aflatoxins in poultry feed, poultry litter samples and the livers of chickens has been reported in South Africa (Westlake & Dutton, 1985).

According to Bhattacharya & Taylor (1975) poultry are potential carriers of several human pathogens, which have been found in poultry waste. These include the following: viruses of New Castle disease and Chlamydia which, respectively, cause conjunctivitis and pneumonia in human; *Erysipelothrix rhusiopathia*, which produces erysipelas; *Listeria monocytogenes*, the agent causing listeriosis; *Mycobacterium avium*, one of the agents that occasionally produces human tuberculosis or causes tuberculin sensitivity without disease; *Candida albicans*, the causative agent of a fungal disease, candidiasis, with symptoms of oral lesions, vaginitis, skin lesions and bronchopulmonary infection;

*Aspergillus fumigatus*, which causes rhinitis, asthma and chronic pulmonary disorder; *Clostridium botulinum*, which produces food poisoning and *Salmonella* spp., which causes enteritis infection in man.

Ogonowski *et al.* (1984) analysed 813 South African fresh poultry manure and litter samples for the presence of micro-organisms. The micro-organisms found included *Clostridia* species in 0.37 percent, *E. coli* in 0.49 percent, *Staphylococcus* in 0.25 percent and *Salmonella* in 12.3 percent of the samples. The *Clostridia* species produces botulism causing toxins. Botulism is a common problem in ruminants eating unsterilised poultry litter. The source of the *Clostridia* species is dead rodents, chicks, partly hatched eggs, etc. found in the manure/litter (Oosthuizen, 1979). The *Clostridia botulinum* produces a deadly toxin which easily contaminates the litter (Oosthuizen, 1979). It is important that animals be vaccinated twice against botulism before they are fed litter, five weeks and one week before the start of feeding the litter (Van der Lugt *et al.*, 1996).

Products of animal origin can be a source of *Salmonella* infection. However, the pathogen is destroyed by heat and dehydration and should not be a problem if the litter fed, is dry (Wuethrich, 1978).

Processing of the litter destroys pathogens and improves the keeping quality and palatability of the litter (McClure & Fontenot, 1987; Lober *et al.*, 1992; Chaudhry *et al.*, 1996). Fontenot & Webb (1974) indicated that pathogens such as *Arizona* spp., *Salmonella pullorum*, *S. typhimurium* and *Escherichia coli* were destroyed by mild heat

treatment. Jacob *et al.* (1998) demonstrated that pathogenic bacteria intentionally added to litter at levels higher than normally encountered in infected litter were killed when litter was deep stacked for 5 days. Knight *et al.* (1977) showed that deep stacking of broiler litter increased the litter temperature by over 60<sup>0</sup> C and thus destroyed *coliform*, *mycobacterium* and *clostridia* bacteria. Hovatter *et al.* (1979) reported that pathogens were eliminated by deep stacking the litter alone. A similar result was indicated by Caswell *et al.* (1977) when the litter was ensiled at different moisture levels alone or in combination with high moisture grain. Carter & Poore (1998) recommended that the litter be deep stacked for at least three weeks.

#### **1.4.4 Carry-over of drugs**

##### **Pesticides**

Pesticides are sometimes used in poultry houses or are applied on the litter to combat insects in the manure. Messer *et al.* (1971) reported the presence of DDT and DDE in 10 poultry litter samples. Fontenot *et al.* (1971) found negligible amounts of pesticides in broiler litter and suggested that the feeding of rations containing 25 or 50 percent broiler litter did not have a substantial effect on pesticide accumulation in the liver or omental fat of cattle. Similar results were reported by El-Sabban *et al.* (1970) when steers were fed processed hen manure. It seems from the literature that pesticide residues in the litter do not seriously handicap the use of poultry waste as a feedstuff.

## Drugs and residues

Drugs are used for medicinal purposes and improvement of growth and feed efficiency (Fontenot & Jurubescu, 1980). Webb & Fontenot (1975) observed that medicinal drugs were present in broiler litter when broiler diet composition included medicinal drugs. Elmund *et al.* (1971) reported as much as 75 percent of chlortetracycline in the diet being excreted in the manure by steers. Messer *et al.* (1971) found levels ranging from 10.2 to 25.1 mg/kg of furazolidone and 4.5 to 26.7 mg/kg nitrofurazone in litter samples taken from different poultry farms. However, the residues (chlortetracycline, micarbazin and amprolium) have not been reported to accumulate in edible tissue of finishing steers slaughtered after a five-day withdrawal period (Webb & Fontenot, 1975). This suggests that at least a five-day withdrawal period is required before slaughter when poultry waste is fed to finishing steers. In USA a 15 day withdrawal period before slaughter is required on animal waste containing drug residues if it is destined for feeding, and must carry a label to that effect (Ruffin & McCaskey, 1998). Since these nitrofurans do not accumulate in body tissue, there is a possibility that these compounds may appear in fairly large quantities in poultry manure (Calvert, 1971). However, what effect they might have on the animal consuming the manure is not known. Bare *et al.* (1964) studied low levels of bacitracin and penicillin and found that after continuous feeding of 11 mg/kg of bacitracin and 44 mg/kg penicillin there was a marked difference in the amount of these two compounds in the intestine, with the level of bacitracin remaining unchanged. It appeared that bacitracin was more resistant to deactivation compared to penicillin. From these results it would appear that some antibiotics are excreted in fairly large quantities and

others are not. If poultry waste is fed to cattle, sheep and goats the carry-over effect of these antibiotics contained in broiler litter needs to be understood.

Compounds like quaternary ammonium, sodium propionate and nystatin are added to feeds to prevent mould growth (Calvert, 1971). However, the amounts are small and it is unlikely that they may present problems to the animals eating the litter.

Broad spectrum, absorbable antibiotics are the same as mentioned above, but they are used at higher levels for short periods. They are used for treatment of diseases and are not fed continuously. However, they may end up in the litter thus posing a potential problem to the animals consuming the litter.

Worming drugs used to treat parasite infections in poultry may include sulphur drugs, sulfaquinoxaline and sulfanitran. According to Calvert (1971) not much is known about these compounds once they leave the gut. They may, however, pose a problem if found in litter fed to animals.

### **Coccidiostats**

Feeding of broiler litter has been associated with mortalities due to botulism, copper toxicity and salmonellosis (Fourie *et al.*, 1991). Mortalities that could not be ascribed to any of the above causes were reported between 1986 and 1990 in South Africa in cattle and sheep fed poultry litter (Bastianello *et al.*, 1995). The problem could be traced to broiler litter containing a coccidiostat, maduramicin, which was added to broiler feed

(Fourie *et al.*, 1991). Upon consumption of diets containing such litter, cattle and sheep become intoxicated and the symptoms of the toxicity included dilated cardiomyopathy with congestive heart failure and mild to severe skeletal muscle lesions (Bastianello *et al.*, 1995). Nel (1989) observed that the coccidiostat became a problem when more than 20 percent broiler litter containing 5 mg/kg (5ppm) maduramicin was included in a stock ration.

Phelps (1990) pointed out that a coccidiostat may not all be absorbed from the broiler digestive system, resulting in some of it being voided with the faeces. Since the same drug may also be included in a ruminant's diet as a ionophore, the inclusion of high levels of litter containing the drug may result in the consumption of dangerously high levels of the drug (Phelps, 1990).

Van Ryssen (1991) studied the effect of monensin and its metabolites in broiler litter on sheep consuming the litter. He concluded that residues of this coccidiostat in broiler litter did not seem to cause a problem in ruminants consuming the litter.

## **Hormones**

Hormones are not widely used in poultry feed (Calvert, 1971), available information seems to be published up to the early 1970's. On occasion some hormones may be added for specific purposes in poultry diets. Iodinated casein has been used to simulate the action of thyroxin (Calvert, 1971). Thyouracil, though not a hormone, may be added to diets to suppress thyroid activity and increase fertility in hens (Marks, 1968). Dinesterol

diacetate is added to finishing broiler feeds (Calvert, 1971). This compound has oestrogenic activity (Calvert, 1971). If it appears in the manure it may pose problems for the animals eating the litter. Abortion has been reported in cows fed broiler litter (Griel *et al.*, 1969). The litter was indicated to have had oestrogenic activity of 10 mg per 100 g as compared to 1 mg per 100 g in forage crops (Griel *et al.* 1969). The effect, in this case, was suspected to be due to the incorporation of diesterol diacetate in roaster feed mixed to contain 150 to 250 mg/kg of a premix containing 14 percent diesterol diacetate (Bhattacharya & Taylor, 1975). Presence of oestrogenic hormones in hen faeces has been reported (Hertelendy *et al.*, 1965). According to Oosthuizen (1979) litter/faeces containing oestrogenic activity must be from sexually mature fowls and the reported abortions may be due to hormonal imbalance. Although the fact of poultry litter causing abortion in animals fed the litter is not substantiated it cannot be ignored as a possible danger (Oosthuizen, 1979). Abortion may also be of fungal origin. According to Lowry (1992) broiler litter is a good source of cheap protein. However, abortion cases caused by a fungus, *Ospergillios* spp, which occurs in most poultry litter, could be encountered when broiler litter is fed to ruminants.

A high incidence of abortion was reported in cows fed low levels of poultry litter in their wintering ration and grazing pasture in summer which had been fertilised with poultry litter (Fontenot & Jurubescu, 1980). Abortions were suspected to be due to dienoestrol acetate fed to birds and resulted in oestrogenic activity in the litter (Fontenot & Jurubescu, 1980). However, the cause of the abortion was not established, but blamed on a hormonal imbalance.



#### **1.4.5 Conclusion**

In conclusion, it has been demonstrated conclusively that poultry litter can be used as a feedstuff for ruminant animals. However, most of the research on poultry litter as a feedstuff for ruminants has demonstrated only a potential hazard in sheep fed poultry waste with high levels of copper (; Drake *et al.*, 1965; Fontenot *et al.*, 1966; Fontenot *et al.*, 1971 Webb *et al.*, 1973; Cullison *et al.*, 1976; Olson *et al.*, 1984). No transmission of toxic effects from livestock to man has been demonstrated as a result of feeding of poultry litter (Fontenot & Webb, 1975).

Pugh *et al.* (1994) stated that the feeding of poultry litter is associated with a few health problems, hypocalcaemia, salmonellosis, copper toxicosis and gastrointestinal impactions.

### **1.5. LEGAL ASPECTS REGARDING THE FEEDING OF POULTRY LITTER**

#### **1.5.1 South African situation**

South African Act 36 of 1947 states very clearly that no product originating from animals can be sold as an animal feed unless it has been registered as an animal feed. The Act stipulates that a registered farm feed, such as poultry manure, must be sterilised (Ogonowski *et al.*, 1984). This requires the product to meet certain nutritional and hygienic standards. The Act specifies that broiler litter should have a moisture content of 120 g/kg (maximum), crude protein 240 g/kg (minimum), crude protein from uric acid 600 g/kg (maximum), fat 15 g/kg (minimum), fibre 150 g/kg (maximum), ash 150 g/kg

(maximum), feathers 10 g/kg (maximum), calcium 35 g/kg (maximum), phosphorus 15 g/kg (minimum), sodium 5 g/kg (maximum), silica 5 g/kg (maximum) and copper 50 mg/kg (maximum). Twenty thousand micro-organisms /g is deemed pathogen free according to the Act. The requirements for layer manure are similar to those of broiler litter except for the crude protein (220 g/kg), ash (250 g/kg), calcium (80 g/kg) and phosphorus (20 g/kg) concentrations. Feed suppliers have to comply with this law. Feed consultants are legally not permitted to recommend the feeding of unregistered litter (Government Gazette, 1980). However, legislation does not prevent farmers from buying poultry litter as a fertiliser or have it available on the farm and use it as an animal feed.

### **1.5.2 Legal aspects elsewhere in world**

Besides South Africa the use of poultry manure as a feed has been reported in Canada (Anonymous, Feedstuffs, 1967) and Australia (McInnes *et al.*, 1968). In England, poultry manure was marketed as TOPLAN (Zindel & Flegal, 1971). The British Agricultural Research Council suggested that poultry manure be fed at the rates of 50 percent TOPLAN to 50 percent barley for cattle and sheep production and for dairy cattle at the rate of 25 percent TOPLAN to 75 percent barley (Smith, 1971). The use of poultry manure as feed for animals has since been completely banned in the United Kingdom and Europe. In USA a 15-day withdrawal period before slaughter is required on animals that were fed poultry manure diets (Fontenot, 1991).

## 1.6. MOTIVATION

Disaster droughts have a frequent occurrence in Southern Africa. On top of this, devastating veld fires are often destroying huge areas of grassland during the dry winter periods following a good rainy summer. Therefore, stock farmers frequently have to resort to emergency feeding measures to maintain their animals, i.e. following survival feeding strategies, amongst others by making do with what feed is available such as poultry litter.

Poultry farming is one of the livestock enterprises which is very successfully conducted in rural areas. Although poultry manure can be used as a fertiliser, these products are available during droughts and can be used as animal feed. Furthermore, most larger poultry units have an abundance of litter material. The product can often be obtained free of charge or at least at a very reasonable price compared to other feed ingredients.

Under survival feeding conditions farmers will resort to feeding of chicken litter quite often as the only feed (Bishop *et al.*, 1971). Chicken litter is not an ideal feed, being classified as a bulky protein concentrate. It is low in energy; high in some minerals; it may contain coccidiostats, antibiotics and drugs, hormones etc. and therefore it is assumed that feeding of the litter as the sole feed may have harmful consequences to the animals. In the investigations reported in this document it is assumed that it is a *de facto* fact that farmers will use the unregistered product. The product used is usually stored outdoors, under high temperatures and dry atmospheric conditions.

- (i) Because of its low energy content, feeding of the litter would result in increased levels of ammonia in the rumen thus increasing the amount of ammonia absorbed from the rumen resulting in an increased burden on the liver.
- (ii) The utilisation of the increased ammonia level in the rumen can be improved by feeding the litter together with easily available energy sources (molasses or starch).
- (iii) Because of its high mineral content, feeding of the litter could lead to accumulation of toxic minerals in animal body and also affect carcass characteristics.

Based on practical observations it is hypothesised that broiler litter can constitute a high proportion of a ration. However, attention needs to be paid to many possible health problems related to the feeding of litter. It is argued that instead of condemning the use of broiler litter as feed, it must be accepted that farmers in South Africa are feeding it to their livestock. Therefore, although an animal scientist in South Africa is prohibited by law to recommend the feeding of unregistered broiler litter, he must have the knowledge to advise farmers using it. This series of trials were thus conducted to elucidate:-

- (1) The health aspects of feeding broiler litter as a survival feed, i.e. the effects of feeding high broiler litter levels on health aspects in the body of sheep.
- (2) The metabolism and utilisation of the chicken litter by microbes in the rumen and in the rest of the digestive track and methods to modify it.

- (3) The effect of broiler litter feeding as a survival feed on carcass characteristics as some farmers may respond to a drought situation by reducing their stock numbers and culled animals may end up in the abattoir.