CHAPTER 3

3.0 SITE AND EXTENT OF DIGESTION OF BROILER LITTER FED WITH OR WITHOUT MOLASSES AS A SURVIVAL FEEDING STRATEGY IN SHEEP

3.1 INTRODUCTION

In arid countries with long dry seasons and frequent occurrence of droughts, poultry litter is used often as a feedstuff for ruminants (Silanikove & Tiomkin, 1992; Deshck *et al.*, 1998). It sometimes constitutes the main source of nutrients for the animals (Silanikove & Tiomkin, 1992). Similar situations exist in Southern Africa in particular during protracted droughts or when devastating veld fires have destroyed vast areas of natural grazing. Farmers then have to resort to emergency feeding measures, which would prompt them to feed any available product such as poultry manure to keep their livestock alive (Chapter 2).

The potential problems with poultry manure or litter as a feedstuff have been investigated extensively. These studies emphasised the precautionary measures required in the feeding of such a nutritionally unbalanced group of products which may possess numerous potential health risks to the animal (Caswell *et al.*, 1997; Fontenot & Jurubescu, 1980; Fontenot, 1991; Rankins *et al.*, 1993; Ruffin & McCaskey, 1998).

Broiler litter has a high crude protein content, mainly non-protein nitrogen, and is deficient in available energy (Fontenot, 1991). The high crude protein and low available energy content in the litter could impair the efficient utilisation of the ammonia by ruminal micro-organisms and thus by the animal. To investigate the utilisation of the nutrients in broiler litter under such a situation, the partition of digestion in the gut was studied with sheep fed broiler litter alone or mixed with molasses.

3.2 MATERIALS AND METHODS

3.2.1 Animals and treatments

Six mature SA Mutton Merino wethers (*ca.* 54 kg body weight) fitted with ruminal and T-type abomasal and terminal ileal cannily were adapted to a 100% broiler litter diet. At the onset of the trial the wethers were randomly allocated to three treatments: pure broiler litter and the litter mixed with 7.5% or 15% molasses. Sun-dried broiler litter with wood shavings as bedding materials was used. The litter was sifted through a 2.5 cm sieve to remove lumps and foreign material. Experimental diets were prepared by mixing the litter with 0, 7.5 and 15 percent liquid molasses (by weight) in a vertical feed mixer. A 3 x 3 Latin square design was used, giving two wethers per treatment per period and six animals per treatment at completion of the trial. Three weeks prior to the trial the sheep were vaccinated against botulism and dosed with a broad spectrum anthelmintic. Between each collection period a 14-days adaptation period on the next experimental diet was allowed before the sheep were placed in metabolism crates and fitted with harnesses for

faecal collection. The sheep received the diets *ad libitum*, supplied four times a day, and had free access to water. Feed intake was recorded and representative feed samples were taken. The experiment was conducted under the supervision and approval of the Ethics Committee for Animal Experimentation of the University of Pretoria.

The double marker technique was used in the partial digestion study (Faichney, 1975) with chromium-EDTA (Downes & McDonald, 1964) and ytterbium - acetate (Siddons *et al.*, 1985) as liquid phase and particulate phase markers respectively. The chromium-EDTA and ytterbium-acetate were prepared according to the methods described by Morgan *et al.* (1976). The concentrated chromium solution contained approximately 16000 mg chromium/l and the concentrated ytterbium solution 7750 mg ytterbium/l. The actual concentration of chromium and ytterbium in the solutions were determined by atomic absorption spectrophotometry. At the onset of the infusion period a priming dose of each of the concentrated solutions (20 ml of the chromium and 10 ml of the ytterbium solutions) were introduced directly into the rumen; thereafter, the concentrated solutions (15 ml chromium-EDTA and 10 ml ytterbium per day) diluted with distilled water (2000 ml) were infused with the aid of an electrical peristaltic proportioning pump. This ensured that about 240 mg chromium and 77.5 mg ytterbium were infused per sheep per day. From day five of infusion, ruminal, abomasal and ileal contents were collected over a period of four days. This was done according to a predetermined schedule to avoid unduly disturbance of the animals and flow of digesta, but ensured the collection of a ruminal, abomasal and ileal sample every three hours of a 24-hour period. Sampling times on day 5 were at 9:00 and 21:00; on day 6 at 12:00 and 24:00; on day 7 at 15:00

and 03:00; and on day 8 at 18:00 and 06:00 hours. Immediately after collection of ruminal samples, pH was measured. Thereafter, ruminal content was strained through six layers of cheese cloth. Twenty five ml of the rumen liquor were preserved with 25% ortho-phosphoric acid (1 ml to 9 ml of sample) for volatile fatty acid (VFA) analyses (Grimaud & Doreau, 1995) and another 25 ml with 50% (v/v) sulphuric acid (1ml to 9 ml of sample) for an ammonia nitrogen assay. Fifty ml each of abomasal and ileal digesta were collected at each sampling and frozen at -20^0C. Faeces were collected twice a day and 10% aliquot per collection was stored at -20^0C.

3.2.2 Analytical procedures

After thawing, composite samples (20 ml each) of abomasal and ileal digesta were centrifuged and the supernatant stored at -20^0C pending chromium, ytterbium, and ammonia nitrogen analysis. Chromium, ytterbium and ammonia nitrogen concentrations in broiler litter (chromium only), supernatant, composite abomasal and ileal samples were determined with an auto analyser (Technicon Auto Analyser II; Industrial method No. 334- 74A). Concentrations of VFA in the ruminal fluid were assayed using a gas chromatograph with a FFAP column (25m X O.53mm), injector and detector temperatures 230^0C and 250^0C, respectively, and nitrogen flow set at 15 ml/minute). The DM, organic matter and nitrogen concentrations in the feed, composite abomasal, ileal and faecal samples were obtained using the standard A.O.A.C. (1990) procedures. The uric acid was extracted from the litter using the method of Eiteman *et al.* (1994) and then determined by the capillary zone electrophoresis method of Shihabi *et al.* (1995). Based on the 100% recovery of samples spiked with uric acid, it was concluded that this method

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was successful in measuring the uric acid concentration in litter. However, the method appeared unsuitable for the abomasal content because only a 20% recovery of spiked uric acid could be achieved on those samples. True protein concentration was obtained with a protein precipitation method using trichloroacetic acid (Faichney & White, 1983; Marais & Evenwell, 1983). However, the method states that uric acid will precipitate with the protein. Amino acid composition of the litter was read on an amino acid analyser (Hewlett Packard 3D CE capillary electrophoresis). Neutral detergent fibre and acid detergent fibre concentrations in the diets were determined according to the procedure of Robertson & Van Soest (1981). The abomasal samples were assayed for purine-nitrogen according to the procedure of Zinn & Owens (1986). Calcium, phosphorus, magnesium, copper, sodium, manganese, potassium and zinc concentrations in the diets were obtained as described in Chapter 2. Total non-structural carbohydrate (TNC) concentrations in the litter were determined according to the procedure of Harris (1970). A hydride generator attached to an atomic absorption spectrophotometer was used in the assay for selenium concentration in the diets. The dry sieve technique with a maximum sieve diameter of 2 mm was used to measure the distribution of particle sizes of the litter.

3.2.3 Calculations

The abomasal and the ileal digesta flows were calculated by reference to chromium as liquid phase marker and ytterbium as particulate marker (Faichney, 1975). Total digesta were reconstituted according to marker concentrations in fractionated and unfractionated

digesta. Large intestines digesta flow was calculated by difference between ileal and faecal digesta flows and nutrient disappearances by difference for the rumen, small and large intestines. Microbial nitrogen flow was estimated from the purine nitrogen flow in the abomasum (Zinn & Owens, 1986). A factor, 0.3133, was developed from the purine nitrogen: total nitrogen ratio in isolated rumen bacteria, collected from sheep on a 100 percent broiler litter diet. To estimate the purine nitrogen flow 1200 ml rumen fluid was collected from separate ruminally cannulated sheep (50 ml per collection) at 6.00 hours, 9.00 hours, 12.00 hours, 15 hours, 18.00 hours, 21.00 hours and 24.00 hours staggered to avoid unduly disturbance of the animals over 12 days with two collections per day. Thawed samples were centrifuged at 2000 rpm for 5 minutes and supernatant harvested. The supernatant was centrifuged at 8000 rpm for 30 minutes and supernatant decanted. The remaining solid was washed with distilled water, centrifuged (as above) and supernatant decanted. This procedure was repeated two times. The remaining microbes were washed into a container, freeze dried and then analysed for purine and total nitrogen. The efficiency of microbial nitrogen synthesis was estimated from the microbial nitrogen flow in the abomasum per kg of organic matter apparently digested in the rumen. Non-ammonia nitrogen represents a true protein concentration and is the difference between total nitrogen and ammonia nitrogen flows at a specific site.

3.2.4 Statistics

Statistical analyses were conducted according to the Latin square design using the Statistical Analysis System (1994) and a Tukey test to test the significance of differences. Due to the inherently large variations encountered with marker technique as in partial

digestion studies (Titgemeyer, 1997) total faecal recoveries of nitrogen and organic matter were compared with recoveries calculated from marker concentrations in faeces. When obvious out-liers in the latter were excluded, the nitrogen and organic matter recoveries between marker and total faecal collections corresponded well (Titgemeyer, 1997). Results from these sheep were omitted also in calculations based on data from the abomasal and ileal collections.

3.3 RESULTS

The chemical composition of the diets is presented in Table 3.1. The addition of molasses did not change the composition of the litter substantially, except for slight increases in TNC and potassium concentration with the addition of molasses. The chromium concentration in the litter was negligibly low and therefore not subtracted in the calculations of flow rate of the liquid phase. The particle size of 41 percent of the pure litter was > 2mm and 52 percent > 1 mm. The composition of the nitrogen fraction in the pure litter is presented in Table 3.2. The true protein concentration represented 47.6 percent of total nitrogen in the litter. The total amino acid and total true protein concentrations were 95.9 and 104.8 g/kg DM respectively. The uric acid concentration in the pure litter was 9.69 g/kg DM, equivalent to 9.2 percent of total nitrogen.

The DM intake increased ($p < 0.05$) with molasses addition (Table 3.3) and constituted 1.9, 2.4 and 3.0 percent of the sheep body weight for the 100, 92.5 and 85 percent litter treatment respectively. The intakes were reflected in higher ($p < 0.05$) flow rates of

digesta through the abomasum and ileum of the high molasses treatment, but not in faecal output (Table 3.4). Despite the increased intakes, the average pH of the ruminal contents and the VFA and ammonia-nitrogen concentration in ruminal fluid did not differ among treatments (Table 3.3).

Although total nitrogen intake was higher at 15 percent molasses inclusion than in the other treatments, differences were not statistically significant (Table 3.5).

Table 3.1: The chemical composition of broiler litter containing diets (Dry matter basis)

Broiler litter(%)	100	92.5	85
Molasses (%)	0	7.5	15
Dry matter (g/kg)	850	880	830
Organic matter (g/kg)	820	830	820
Crude protein (g/kg)	190	210	200
NDF (g/kg)	410	410	400
ADF (g/kg)	280	250	230
TNC (g/kg)	120	140	190
Calcium (g/kg)	13	18	14
Phosphorus (g/kg)	13	13	12
Magnesium (g/kg)	2	2	3
Potassium (g/kg)	11.2	13.5	15.1
Sodium (g/kg)	2.4	2.2	2.7
Manganese (mg/kg)	290	267	250
Copper (mg/kg)	58	49	51
Selenium (mg/kg)	0.94	0.97	1.07
Zinc (mg/kg)	222	253	252

NDF = Neutral detergent fibre; ADF = Acid detergent fibre;

TNC = Total non-structural carbohydrates

Table 3.2: Composition of nitrogen fractions in pure broiler litter (Dry matter basis)

Nitrogen fraction	g/kg
Crude protein	220.0
True protein	104.8
True crude protein (of total N)	476.0
Uric acid	9.69
Uric acid nitrogen	3.23
Total amino acids	94.9
Alanine	7.3
Arginine	4.0
Aspartic acid	7.9
Glutamic acid	14.1
Glycine	8.3
Histidine	1.5
Isoluecine	4.7
Leucine	8.0
Lysine	5.3
Methionine	1.7
Phenylalanine	4.9
Proline	7.0
Serine	6.8
Threonine	5.2
Tyrosine	2.2
Valine	6.0

Table 3.3: Feed intake, pH of ruminal content and ammonia and volatile fatty acid (VFA) concentrations in ruminal fluid*

Broiler litter(%)	100	92.5	85
Molasses(%)	0	7.5	15
Dry matter intake (g/d)	858.4[a]	1123.1[a]	1365.9[b]
Nitrogen intake (g/d)	31.3	44	52
Ruminal fluid pH	6.8	6.9	6.7
Ruminal fluid $NH_3 - N$ (mg/100 ml)	51.4	56.4	51
Volatile fatty acids			
Total VFA (mMOL/100ml)	17.4	22.7	23.02
Acetic acid (Molar)	0.652	0.666	0.657
Propionic acid (Molar)	0.235	0.199	0.206
N-butyric acid (Molar)	0.075	0.095	0.106
Iso-butyric acid (Molar)	0.015	0.013	0.008
N-valeric acid (Molar)	0.009	0.009	0.009
Iso-valeric acid (Molar)	0.014	0.011	0.009

*Means within a row with different superscripts are statistically different at $P<0.05$

Table 3.4: Digesta flow at various sites of the gastrointestinal tract*

Broiler litter(%)	100	92.5	85	MSE	p<
Molasses(%)	0	7.5	15		
Abomasum(l/d)	9.9^a	11.3^a	20.1^b	5	0.05
Ileum (l/d)	3.5	4.2	4.2	1.1	NS
Faecal output(g/d)	518.5	568.2	559	123	NS

*Means in the same row with different superscripts are different P<0.05

The flow rates of total nitrogen, non ammonia nitrogen and microbial nitrogen through the abomasum were higher (p<0.05) in the 85 percent (p<0.05) litter treatment compared to the other two treatment (Table 3.5). This trend was not evident in the ileum. A smaller (p<0.05) percentage of nitrogen (24 percent) disappeared from the rumen when the 85 percent litter diet was fed compared to when 100 (55%) and 92.5 (59%) percent litter treatments were given. In the small intestine a higher (p<0.05) percentage of total dietary nitrogen disappeared from the 85 percent litter diet than from the other two diets, viz. 40 versus 18 and 11 percent, respectively. Apparent digestibility of total dietary nitrogen in the whole tract was between 72 and 73 percent with no significant differences among treatments (Table 3.5). When the 85 percent litter diet was fed, microbial nitrogen flow in the abomasum was 16.2 g/day which was significantly higher (p<0.05) than in the 100 and 92.5 percent treatments (8.5 and 10.4 g nitrogen/day) respectively. The quantity of ruminal microbial nitrogen apparently synthesised per kg of organic matter digested in

the rumen was 27.8, 16.1 and 75.3g for the 100, 92.5 and 85 percent litter diets respectively.

Table 3.5: Intake, flow, non ammonia (NAN) and ammonia nitrogen flows and apparent digestion of nitrogen (N) in the gastrointestinal tract*

Broiler litter(%)	100	92.5	85	MSE	p<
Molasses (%)	0	7.5	15		
N-intake (g/d)	31	44	52	16	NS
Nitrogen flow (g/d)					
At abomasums	14^a	18^a	39^b	11	0.05
At ileum	6	11	15	6	NS
NAN flow (g/d)					
At abomasums	11^a	15^a	34^b	10	0.05
At ileum	5	6	6	1	NS
Microbial-N flow (g/d)					
Abomasum	8.5^a	10.4^a	16^b	4	0.05
Apparent digestion (g/d)					
Rumen	17^{ab}	26^a	13^b	5	0.05
Small intestine (NAN)	6^a	9^a	28^b	5	0.05
Digestion coefficients (%)					
Rumen	55^a	59^a	24^b	12	0.05
Small intestine (NAN)	18^a	11^a	40^b	14	0.05
Total track nitrogen	72	72	73	4	

*Means on the same row with different superscripts are significantly different.

Table 3.6: Intake, flow and apparent digestion of organic matter in the gastrointestinal tract*

Broiler litter(%)	100	92.5	85	MSE	p<
Molasses (%)	0	7.5	15		
Organic matter intake (g/d)	730^a	988^a	1134^b	290	0.05
Total flow (g/d)					
At abomasums	458^a	531^a	901^b	342	0.05
At ileum	341^a	450^a	509^b	148	0.05
Faecal output	269	379	421	86	NS
Apparent digestion (g/d)					
In rumen	272^a	457^b	233	419	NS
In small intestine	117^a	81^a	392^b	288	0.05
In large intestine	42^a	71^a	88^b	52	0.05
In total tract	431^a	609^a	731^b	354	0.05
Site of digestion (% of total)					
Rumen	63^a	75^a	32^b	13	0.05
Small intestine	27^b	13^b	54^a	11	0.05
Large intestine	10	12	12	8	0.05
Digestibility coefficients (%)					
Rumen	37^a	46^a	21^b	10	0.05
Small intestine	16^a	8^a	35^b	16	0.05
Large intestine	6	7	8	6	NS
Total tract	59	62	64	26	NS

* Means on the same row with different superscripts are different (p<0.05)

The total quantity of dietary organic matter (Table 3.6) that disappeared in the rumen differed ($p < 0.05$) between treatment: a lower ($p<0.05$) percentage (21%) of dietary organic matter disappeared in the rumen from the 85 percent litter compared to 37 and 46 percent from the 100 and 92.5 percent litter diets respectively Table 3.6). On the other hand, a higher ($p<0.05$) percentage (35%) of organic matter was apparently digested in the small intestines when the sheep received the 85 percent litter than the 16 and 8 percent when the 100 and 92.5 percent litter diets were fed respectively (Table 3.6). However, the apparent digestibility of organic matter in the total digestive tract did not differ among treatments and ranged from 59 to 64 percent.

3.4 DISCUSSION

The litter used in the present study contained 20 percent crude protein. This is relatively low in comparison with the concentrations usually quoted for the product in other countries, e.g. 30 percent in Israel (Silanikove & Tiomkin, 1992), 30 to 32 percent in the USA (Bhattacharya & Fontenot, 1966; Rude & Rankins 1997). However, it corresponded with crude protein concentrations recorded in South Africa (Van Ryssen *et al.*, 1977). The 48 percent true protein in crude protein in the present study corresponded well with the value of 45.4 percent reported by Bhattacharya & Fontenot (1966) and 50 to 60 percent reported by Van Ryssen *et al.* (1977). The amino acid composition of the pure broiler litter sample agreed well with analyses quoted by Bhattacharya & Fontenot (1966)

and Wuethrich (1978). However, the uric acid (nitrogen x 6.25) constituting 9.2 percent of total crude protein in the litter is substantially lower than the 28.8 to 30.5 percent reported by Bhattacharya & Fontenot (1966), the 45.7 percent calculated from data presented by Wuethrich (1978) and the 36.5 percent calculated from the data of Zinn *et al.* (1996). It is usually assumed that poultry excreta nitrogen contains a high proportion, up to 87 percent, of uric acid (Oltjen & Dinius, 1976). In our assay the uric acid-spiked samples gave a 100 percent recovery of added uric acid. The true protein concentration which includes uric acid (Faichney & White, 1983) was very similar to the sum of the amino acids in the sample. This supports the result of a low uric acid concentration in our litter. According to Oltjen & Dinius (1976) uric acid in wet droppings tends to decompose rapidly to urea and ammonia with the consequent wide variation in uric acid concentration in poultry waste. In the present study the relative slow drying of the litter in the sun could have decreased the uric acid as well as total crude protein concentrations.

The crude protein, calcium and phosphorus concentrations of the molasses diets were recorded as above that of the pure litter diet. This was possibly due to experimental error in the case of crude protein concentration. Calcium and phosphorus concentrations tended to increase when molasses was added to the diets in the experiments reported in this document. This suggests that the molasses used contained these minerals.

Voluntary DM intake increased with increasing addition of molasses to the broiler litter. This agrees with results from our previous study (Chapter 2). In Israel, Silanikove *et al.* (1987) observed a high intake of litter by beef cows relative to the low digestibility of the

diet. They concluded that the small particle size of broiler litter resulted in its easy escape from the rumen, and suggested that this characteristic of poultry litter would probably add to the relatively high intake capacity they noted. However, the general contention in the USA seems to be that 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 problem not observed in our series of trial, using sheep (Chapter 2 and unpublished results). Patil *et al.* (1995) postulated that the passage rate of ruminal digesta of diets high in broiler litter (viz. 50%) might be slow when dietary roughage levels are low, with an accompanying low feed intake. The physical characteristics of broiler litter digesta in the rumen (e.g. buoyancy) may not be conducive to rapid ruminal outflow of digesta and moderate to high dietary levels of roughage would be essential to avert this. Patil *et al.* (1995) reported an increase in ruminating time with the increase of level of hay inclusion in diets high in broiler litter. 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). Although the DM intake in our 100 percent litter treatment was only 1.9 percent of body weight, which is relatively low for sheep, no signs of bloat were noticed. A possible explanation could be that the average particle size of our broiler litter was higher and would thus stimulate rumination more than the litter in the USA. In the present study 41 percent of the litter was >2mm in size, while Rossi *et al.* (1996) reported average particle sizes of 1.53, 1.05, 0.85 and 0.79 mm for litter in the USA. These differences in particle size could be the

result of the practice in the USA to rear five to six batches of broilers in a house before the litter is removed (Park *et al.*, 1995; Patil *et al.*, 1995; Rude & Rankins, 1997), while in South Africa a broiler house is cleaned after each batch of birds.

It seems unlikely that the dramatic increase in broiler litter intake with the addition of molasses could be due to improved conditions in the rumen. Ruffin & McCaskey (1998) pointed out that when broiler litter contains less than 12 percent moisture, the ration may be dusty and thus unpalatable to cows. The litter in the present study contained 15 percent moisture. For lack of a better explanation for the increased intake, it is suggested that the molasses might have reduced the dustiness of the litter which made it more acceptable to the sheep.

There seems to be very little information in the literature on nutrient utilisation of broiler litter fed at very high intakes, as investigated in the present study. Therefore, direct comparisons with information from other research were often not possible. In the present study the magnitude of ruminal pH changes was small and never dropped below 6, reflecting the alkaline nature of broiler litter (Harmon *et al.*, 1974; Silanikove *et al.*, 1987) and its high buffering capacity. These pH values agreed with readings taken by Caswell *et al.* (1977), Silanikove & Tiomkin (1992), Patil *et al.* (1995) and Chaudhry *et al.* (1996) on diets containing lower concentrations of litter than the current trial. In the present study the total VFA concentrations in the ruminal fluid varied between 174 and 230 mmol/l which seems high in comparison with other published values. In diets containing between 56 and 69 percent litter, Rossi *et al.* (1996) measured total VFA

concentrations of 84 and 101 mmol/l, Patil *et al.* (1995) reported a concentration of 90 mmol/l in diets containing low levels of broiler litter while Chaudhry *et al.* (1996) recorded 44 mmol VFA/l on diets containing 50 percent litter silage. The proportion of individual VFA's on a molar percentage basis compared well with those in other studies (Caswell *et al.*, 1977; Rossi *et al.*, 1996). Inclusion of litter into diets has reportedly altered rumen fermentation towards increased propionic acid production (Fontenot & Jurubescu, 1980; Rossi *et al.*, 1996), though according to Patil *et al.* (1995) this would vary depending on the dietary characteristics of the rest of the diet. In the present study high proportions of acetic acid were measured, corresponding to the molar proportion for individual VFA's in the ruminants on high roughage diets (Bath & Rook, 1965).

The apparent digestibility of dietary nitrogen was relatively constant at 72 percent for the different treatments. This agreed with estimates (calculated by difference) of 72 and 74 percent reported by Bhattacharya & Fontenot (1966), 67 to 73 percent by Patil *et al.* (1995), 61 to 71 percent by Chaudhry *et al.* (1996) and 84 percent by Zinn *et al.* (1996). The ammonia nitrogen concentrations in ruminal fluid of above 50 mg/100ml in the present study corresponded with the results of Silanikove & Tiomkin (1992) when their beef cows consumed 6 kg of poultry litter with a small quantity of wheat straw per day. These high ammonia nitrogen concentrations imply that large quantities of ammonia would be absorbed through the ruminal wall, requiring an energy consuming process to detoxify the ammonia in the liver (Silanikove & Tiomkin, 1992). This would result also in an overestimation of the crude protein from litter available to the animal and implies an apparent loss of nitrogen from the rumen as ammonia nitrogen (50%) of intake quantities.

Since a large proportion (50%) of the nitrogen in our litter was in the form of non-protein nitrogen, some might have escaped ruminal degradation. In the present study the chemical form of the non-protein nitrogen is largely unknown. Rate of ruminal degradation of uric acid was found to be slow (Oltjen *et al.*, 1968), though Zinn *et al.* (1996) estimated that 96 percent of uric acid is degraded in the rumen. Previously, Jacobs & Leibholz (1977) could not detect uric acid in the digesta leaving the abomasum of the calves fed diets containing uric acid, but speculated that undetected uric acid or allantoin might have accounted for a high nitrogen absorption in the lower digestive tract of their calves. If non-amino acid-non protein nitrogen escaped ruminal degradation, its absorption in the lower digestive tract would be of little value to the animal (Smith & McAllan, 1971).

The total apparent digestibility of organic matter was similar for all treatment diets, ranging from 59 to 64 percent. These values compared well with reported organic matter digestibilities of 64 percent (Fontenot & Jurubescu, 1980), 44 and 47 percent (Patil *et al.*, 1995), 56 and 58 percent (Chaudhry *et al.*, 1996) and 42 to 46 percent (Rossi *et al.*, 1996). If the higher proportion of organic matter digested in the lower digestive tract at the high molasses intake contained non-protein sources, it would benefit the animal compared to the other two treatments. However, there would be less energy available for microbial growth in the rumen. The rate of organic matter digestion in the rumen was lower (32 percent) for the 15 percent litter diet compared to other treatment diets. Organic matter disappearance in the small intestine for the 15 percent molasses diet was higher than in the rumen and other diets organic matter disappearances. It may be concluded that increased litter intakes may lead to increased rate of rumen passage of nutrients thus

resulting in a shift in organic matter digestion towards the lower tract. This was due probably to the increased dry matter intake for the 85 percent litter diet. Molasses contains a high percentage of water-soluble carbohydrates which is fermented rapidly in the rumen (Yan *et al.*, 1996). Since the quantity of ruminal microbial synthesis is controlled by the quantity of the fermentable metabolisable energy (FME) in the organic matter digested in the rumen (AFRC, 1992), proportionally less microbial nitrogen per unit organic matter intake should have been formed at the high than at the lower molasses intakes. Because of the differences in intake, the effect of molasses on ammonia nitrogen utilisation in the rumen could not be established. However, in the present trial substantially more microbial nitrogen (75 g) was apparently synthesised per kg of organic matter digested in the rumen in the 15 percent molasses diet than from the 28 and 16 g/kg organic matter from the other treatments, respectively. According to Titgemeyer (1998) high microbial yields may indicate inaccuracy in the partial digestion study. This was apparently the case in the high molasses treatment. An attractive alternative explanation would have been to suggest that the uric acid escaping ruminal degradation added to the high concentration of purine in the abomasum. However, this could not be the case if a low concentration of uric acid was present in the litter in this trial.

Apparent DM digestibilities of broiler litter of between 65 and 68 percent measured in the present study compared well with the calculated values of 69 to 74 percent reported by Bhattacharya & Fontenot (1966), 50 percent by Rankins *et al.* (1993) and 57 to 58 percent by Rude & Rankins (1997).

The shift in digestion site of organic matter away from the rumen towards the lower tract in this trial appears abnormal and biologically unlikely. However, the increased litter intake per day suggests the possibility of an increased rate of passage from the rumen which may have resulted in the shift in the organic matter site of digestion. Furthermore, the litter particle size leans towards easy rumen passage which would, possibly, be increased by high feed intakes.

The main effect of an addition of molasses to the pure litter was a significant increase in litter intake and consequently a change in site of digestion of the components in the litter away from the rumen to the lower digestive tract. Whether this would be beneficial to the animal is questionable. If a large proportion of the non-protein nitrogen escapes ruminal degradation, such an increased litter intake would be of little value to the animal. In a previous study (Chapter 2) sheep put on more weight when molasses was added to broiler litter than when fed as the sole feed. This was due mainly to the higher DM intake. In a drought feeding situation where a shortage of energy is the primary problem and protein requirements of the animal should be supplied by the microbial protein synthesised in the rumen, it is debatable whether a high intake of litter which is digested in the lower digestive tract, should be aimed for. Therefore, the addition of molasses may be feasible under drought conditions only if litter intake can be restricted or if voluntary litter intake is unacceptably low.