CHAPTER 6

6.0 DIFFERENT LEVELS OF BROILER LITTER IN DIETS OF SHEEP ON WEIGHT GAINS AND CONDITIONS IN THEIR DIGESTIVE TRACTS

6.1 INTRODUCTION

Despite the fact that broiler litter is sold in South Africa as a fertilizer, an estimated 50 percent of the annual sales of broiler litter in Natal is used as a ruminant feedstuff (Kitching, 1986). In feedlot rations the inclusion rate of broiler litter is usually up to 25 percent (Kitching, 1986). Under survival feeding conditions considerably higher proportions of litter are included in the diets of ruminants. Information on the effects of high levels of litter in the diet on carcass parameters and conditions in the digestive system is limited. However, the results of some investigations have been reported on rumen fermentation of diets containing broiler litter (Harmon *et al.*, 1974; Silanikove & Tiomkin, 1992; Patil *et al.*, 1995; Chaudhry *et al.*, 1996). The objectives of the present studies were to investigate the effect of different levels of including broiler litter in diets of sheep on weight gain, digestion, conditions in the rumen and tensile characteristics of the carcass. The latter is reported in the next chapter.

6.2 MATERIALS AND METHODS

6.2.1 Experimental procedure

Experiment 6.1

Thirty six (36) South African Mutton Merino wethers (*ca.* 2years old and ca. 41 kg body mass) were randomly allocated to four treatment diets containing 0, 28, 56 and 85 percent broiler litter. The rations were compiled to represent the situation as is practiced under both normal and drought conditions in South Africa. The control diet contained 60 percent concentrate and 40 percent roughage, representing a normal feedlot finishing diet for sheep. The 28 percent litter diet is representative of a feedlot diet containing broiler litter. The 56 and 85 percent litter diets are representative of survival feeding situations.

The composition of the treatment diets is shown on Table 6.1. Urea was included in the finishing diets to increase the crude protein concentrations. However, these diets could not be formulated on a isonitrogenous basis, and still represent the feeding situations as aimed for, because of the high crude protein concentration of broiler litter.

The preparation of the sun dried broiler litter with wood shavings as bedding material and the pre-experimental treatment of the sheep were similar to those described in Chapters 2 and 3. During the adaptation period and most of the experimental period the sheep were group fed and had free access to water. On two occasions the sheep were placed in individual feeding pens for two-week periods to measure digestibility of diets. During these periods individual feed intake, faecal excretion and feed refusals were measured daily. Feed samples were collected throughout the trial for chemical analyses. Blood

samples were collected on days 0, 38 and 75 of trial following the method as reported in Chapter 2. Initially the sheep were weighed at two week intervals. When the groups were approaching target slaughter weight, they were weighed every week. The wethers were slaughtered on an individual basis when they reached a weight of 55 kg the week before slaughter. The pre-determined fixed slaughter weight was implemented to ensure that the carcass evaluation was done on a comparative weight basis. After slaughter by exsanguination, the individual sections of the digestive tract were tide off and the weights of the full reticulo-rumen, omasum, abomasum, small and large intestines (caecum only) were taken. These sections were then rinsed with running water until clear, drip-dried and weighed to obtain an empty weight. The warm carcasses, livers and kidneys were weighed as well. Representative samples of the digestive tract sections and livers were taken and dried to obtain their DM content. The various measurements conducted on the cold carcasses are described in Chapter 7.

Table 6.1: Composition of the diets fed to sheep in both trials (g/kg)

	Broiler litter (%)			
Ingredients	**0**	**28**	**56**	**85**
Broiler litter	-	280	560	850
Oats hay	400	325	166	-
Maize meal	311	230	124	-
Molasses	150	150	150	150
Sunflower meal	114	-	-	-
Urea	10	5	-	-
Dicalcium phosphate	10	5	-	-
Salt	5	5	-	-

Experiment 6.2

Four mature SA Mutton Merino wethers (*ca.* 60 kg body weight) fitted with ruminal cannulas were allocated in a 4 x 4 Latin square arrangement to the same dietary treatments as in Experiment 6.1. Between collection periods a 21 days adaptation to the next diet was allowed before sampling. During this period sheep received the diets *ad libitum* and had free access to water. Over a period of seven days of sampling, the sheep were fed 1kg of their diet and 500 ml water through ruminal cannulas. The measuring of the pH of rumen content and the sampling of rumen liquor were done at before (0) and 2, 4, 6, 8, 10 and 12 hours after feed introduction into the rumen. To avoid unduly disturbance of the animals, the pH measurement and sampling of the rumen content were done over a period of seven days according to a pre-determined schedule, which ensured a collection from the rumen every two hours of a 12-hour period. Sampling on day 22 was before feeding (0 hour), day 23 at 2 hours, day 24 at 4 hours, day 25 at 6 hours, day 26 at 8 hours, day 27 at 10 hours and day 28 at 12 hours from feeding time. The pH of the rumen content was measured by inserting the pH meter probe into the rumen. Readings were taken at three locations in the rumen. Rumen content was sampled and strained through six layers of cheese cloth. The liquor was treated as reported in Chapter 3 for VFA and ammonia nitrogen determinations.

6.2.2 Laboratory analysis

The following chemical analyses were done according to the techniques referred to in Chapters 2 and 3: free fatty acid concentrations and ß-hydroxybutyrate, aspartate amino transaminase (AST, EC 2.6.1.1) and creatine kinase (CK, EC 2.7.3.2) activities in

plasma; DM, organic matter, crude protein, neutral detergent fibre and acid detergent fibre concentrations in the feed and faeces; the minerals, reported in Table 6.2, in the feed and ammonia nitrogen and VFA concentrations in ruminal fluid. The nonstructural carbohydrate concentration in a diet was calculated by subtracting the crude protein, neutral detergent fibre, acid detergent fibre and fat concentration from the organic matter content of the diet.

6.2.3 Statistical analysis

Data from Experiment 6.1 were subjected to analysis of variance using the Quatro Pro for Windows statistical software (Borland International, 1993). Data from Experiment 6.2 was analyzed according to the Latin Square design using the Statistical Analysis System (1994) and Tukey test was employed to test for significance of differences.

6.3 RESULTS

The chemical composition of the four diets fed in both experiments is presented in Table 6.2. The crude protein concentration of the diets increased with increasing broiler litter levels in the feed. The broiler litter used in the trial contained 240 g crude protein / kg DM. The organic matter and total nonstructural carbohydrate concentrations of the diets tended to decline with increasing levels of the litter in the diets while the mineral concentrations of the diets increased with increasing inclusion rates of the broiler litter.

Table 6.2: Chemical composition of diets fed to sheep on both trials

	Broiler litter (%)			
	0	**28**	**56**	**85**
	g/kg DM			
Dry matter	870	860	860	850
Organic matter	930	910	890	860
Crude protein	140	130	160	210
Neutral detergent fibre	420	370	370	400
Acid detergent fibre	230	210	220	220
Total nonstructural carbohydrates	370	360	300	210
Ether extract	24	23	24	24
Calcium	-	6.6	8.1	13.3
Phosphorus	-	5.4	6.8	10
Magnesium	-	1.4	1.7	2.5
Sodium	-	2.5	1.9	2.1
Potassium	-	12.7	13.7	14.2
	mg /kg DM			
Copper	-	16	29	50
Manganese	-	144	196	245
Selenium	-	0.36	0. 62	1.11
Zinc	-	70	154	244

***Experiment* 6.1**

The first animals reached the slaughter weight at 84 days while the average number of days for the groups up to slaughter was 106, 115, 112 and 155 days for the 0, 28, 56 and 85 percent litter treatments (Table 6.3). Average daily feed intake per sheep over the experimental period for the 28 and 56 percent litter diets was higher ($p < 0.05$) than that of other treatments, but reached the same level during the the second period tested (days 38 to 74). The apparent digestibility of the nutrients in the diets decreased with icreasing levels of broiler litter inclusion, with the exception of crude protein (Table 6.4)

During the first 37 days of the experiment the 85 percent litter group showed very little gain in weight compared to the other treatments, though in the second 37 days gained as well as the other groups (Table 6.4). This is demontrated in Figure 6.1, which depicts the cumulative weight gains of sheep over the first 84 days of the trial. The efficiency of feed conversion followed the same trend as growth with a very low efficiency in the 85 percent litter group during the first 37 days, but an efficiency very similar to that in the other treatments during the second 37 days.

Table 6.3: Average daily feed intake calculated at different experimental periods for the sheep*

	Broiler litter (%)			
	0	**28**	**56**	**85**
Days to slaughter	106	115	112	155
Feed intake (kg/day)				
Entire period	$1.9^{ab} \pm 0.12$	$2.1^{a} \pm 0.23$	$2.1^{a} \pm 0.24$	$2.0^{b} \pm 0.413$
Day 1 to day 37	$1900^{a} \pm 214$	$2035^{b} \pm 314$	$1934^{a} \pm 291$	$1514^{c} \pm 121$
Day 38 to day 74	$1924^{a} \pm 221$	$2104^{b} \pm 326$	$2340^{c} \pm 332$	$2274^{c} \pm 328$

*Means on the same row with different superscripts are different at $p < 0.05$

Table 6.4: Body weight at slaughter, total and daily weight gains and feed conversion for sheep on trial 1

	Broiler litter (%)			
	0	**28**	**56**	**85**
Weight at slaughter (kg)	56 ± 5	54 ± 3	55 ± 6	51± 4
Total weight gain (kg)				
Entire period	13.1^{a} ± 2	10.2^{a} ± 3	12.3^{a} ± 1	6.4^{b} ± 1
1 to 37 days	7.8^{a} ± 3	7.1^{a} ± 4	5.3^{a} ± 2	0.4^{b} ± 0.2
38 to 74 days	5.3^{a} ± 2	3.6^{a} ± 2	6.9^{b} ± 4	6.0^{b} ± 3
Daily weight gain (g)				
Entire period	176^{a} ± 110	162^{a} ± 100	167^{a} ± 100	144^{b} ± 110
1 to 37 days	210^{a} ± 130	194^{a} ± 110	143^{b} ± 100	100^{c} ± 10
38 to 74 days	147^{a} ± 120	100^{b} ± 80	192^{c} ± 110	168^{c} ± 120
Feed conversion				
Entire period	9.24	11.14	12.33	16.51
1 to 37 days	9.0	10.4	13.6	152.0
38 to 74 days	13.06	21.26	12.07	13.39
Apparent digestibility %				
Dry matter	66^{a} ± 2.0	60^{ab} ± 2.3	58^{b} ± 3.6	50^{c} ± 5.1
Organic matter	72 ± 3.1	67 ± 2.4	66 ± 2.8	60 ± 3.1
Crude protein	71 ± 3.0	62 ± 4.1	68 ± 1.6	71 ± 2.3
Neutral detergent fibre	61^{a} ± 3.4	52^{b} ± 3.5	52^{b} ± 3.4	48^{b} ± 5.9
Acid detergent fibre	51^{a} ± 8	42^{a} ± 6	39^{a} ± 7	24^{b} ± 6

*Means within the same row with different superscripts are different at $p < 0.05$

Fresh carcass weights did not differ among treatments. The fresh liver and kidney weights of the two high litter diets were higher ($p < 0.05$) than those of the lower litter treatments (Table 6.5), However, expressed as a percentage of carcass weight these differences were not significant.

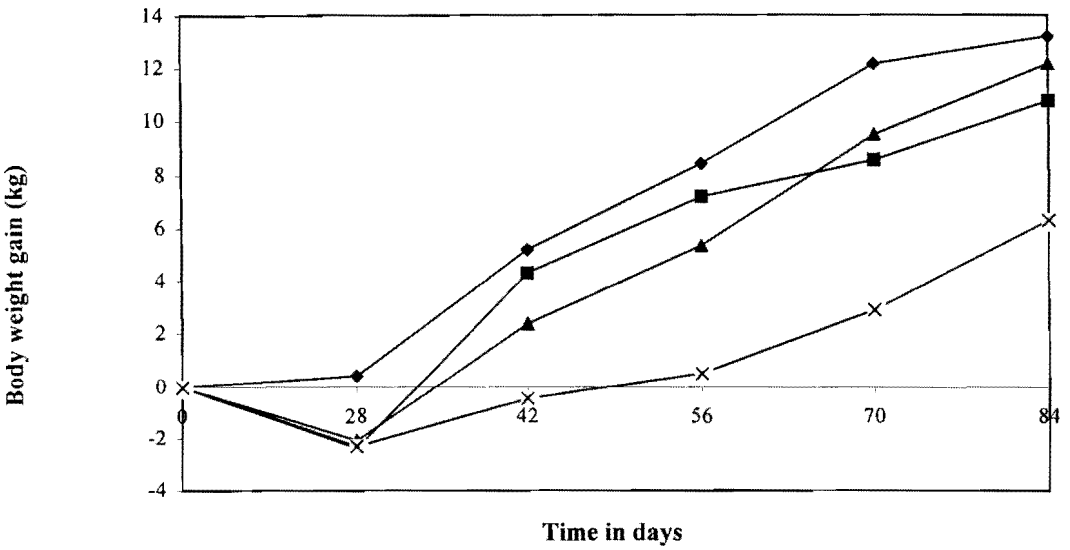


Figure 1: Cumulative weight gain of sheep fed 0% broiler litter (◆), 28% broiler litter (■) 56% broiler litter (▲) and 85% broiler litter (✕) for first 84 days

Table 6.5: Carcass, liver and kidney weights and dressing percentage of sheep fed broiler litter based diets*

	Broiler litter (%)			
	0	**28**	**56**	**85**
Carcass weight (kg)	26 ± 3	27 ± 5	26 ± 7	25 ± 4
Dressing %	48 ± 2	49 ± 3	48 ± 6	47 ± 4
Liver weight (g)	671^{a} ± 25	679^{a} ± 28	758^{b} ± 32	792^{b} ± 39
as % carcass wt.	2.7 ± 0.2	2.7 ± 0.4	3.1 ± 0.3	3.4 ± 0.4
Kidney weight(g)	131^{a} ± 15	120^{a} ± 18	142^{b} ± 23	149^{b} ± 28
as % carcass wt.	0.5 ± 0.03	0.4 ± 0.02	0.6 ± 0.1	0.6 ± 0.3

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

Table 6.6: Full and empty weights of rumen, omasum, abomasum, small and large intestine and their weights expressed as percent of carcass weight*

	Broiler litter (%)			
Parameter	**0**	**28**	**56**	**85**
Rumen (g)				
Full	7428 ± 122	7844 ± 127	8267 ± 127	6450 ± 118
Empty	1132 ± 142	1130 ± 136	1125 ± 128	1076 ± 97
as % carcass wt	4.4	4.2	4.3	4.3
Omasum (g)				
Full	304 ± 58	352 ± 84	340 ± 61	333 ± 33
Empty	131 ± 17	134 ± 27	134 ± 21	127 ± 13
as % carcass wt	0.50	0.50	0.52	0.51
Abomasum (g)				
Full	579^{a} ± 148	697^{b} ± 209	643^{b} ± 175	896^{c} ± 345
Empty	286^{a} ± 39	235^{b} ± 28	268^{ab} ± 58	303^{c} ± 35
as % carcass wt	1.10	0.87	1.03	1.2
Small intestine (g)				
Full	1328 ± 235	1267 ± 330	1540 ± 411	1503 ± 300
Empty	659 ± 76	614 ± 82	507 ± 74	590 ± 60
as % carcass wt	2.53	2.27	2.00	2.36
Large intestine (caecum) (g)				
Full	903 ± 165	928 ± 165	1035 ± 168	1094 ± 187
Empty	224 ± 42	196 ± 49	302 ± 51	198 ± 36
as % carcass wt	0.86	0.73	1.16	0.79

*Means on the same row with different superscripts are different at $p < 0.05$

The weights of the full and empty sections of the digestive tract did not differ among treatments, except for the abomasum (Table 6.6), where the weight of this section increased ($p < 0.05$) with increasing broiler litter content in the diet. At slaughter it was observed that soil had accumulated in the abomasums of the sheep on the high litter diets.

At that stage of the trial, when many of the animals in the other treatment groups were already slaughtered, it did not seem worth quantifying the amount of soil.

No significant differences were observed in the activity of the plasma enzymes measured. Plasma AST activity before and after 74 days into the feeding period for the control, 28, 56, and 85 percent litter diets was 29±2 and 41±3; 25±3 and 45±5; 24±2; 53 ± 5 and 36±3 and 40±6 µmol/l respectively. Plasma CK activity was measured at 21±2 and 50±8; 19±1 and 45±8; 22±2 and 24±1; and 30±6 and 27±4 µmol/l for the control, 28, 56 and 85 percent litter diets, respectively before and after 74 days of experimental period. Plasma ß-hydroxybutyrate activity measured before and after 74 days into the experimental period was noted as 1.6±0.2 and 1.9± 0.1; 1.6±0.1 and 1.9±0.1; 1.9±0.2 and 2.7±0.01; and 1.6±0.2 and 2.2±0.3 mmol/l for the control, 28, 56 and 85 percent litter diets, respectively. Free fatty acids concentration in plasma were indicated as 0.08±0.01 and 0.09±0.01; 0.07 ± 0.01 and 0.09 ±0.01; 0.01±0.01 and 0.13±0.003 and 0.07 ± 0.01 and 0.01 ± 0.01 mmol/l for the control, 28, 56 and 85 percent litter diets, respectively; before and after 74 days of experimental period.

***Experiment* 6.2**

The sheep received an average of 870, 860, 860 and 850 g DM per day for the control, 28, 56 and 85 percent broiler litter diets, respectively. Crude protein intakes for the respective groups were 137, 125, 257 and 210 g/day. Ruminal ammonia nitrogen concentrations for the control, 28 and 56 percent litter diets peaked 2 hours after introduction of feed, while the 85 percent litter group peaked 6 hours from feeding time

(Figure 6.2). The pH of the rumen content (Figure 6.3) remained well above 6.66 throughout the 12 hour period in the 56 and 85 percent litter diets, while that of the control and 28 percent litter diets declined to below pH 6.00 after 6 hours from feed introduction. Total volatile fatty acid production information is presented in Figure 6.4.

Total volatile fatty acid concentration and the concentration of individual volatile fatty acids in the rumen fluid tended to peak at 6 hours for all diets. These peaks were higher in the 56 and 85 percent litter diets than in the low litter diets (Figures 6.5; 6.6; 6.7 and 6.8). In general it appears as if the peaks were more pronounced in the 85 percent litter diet than in the other ones.

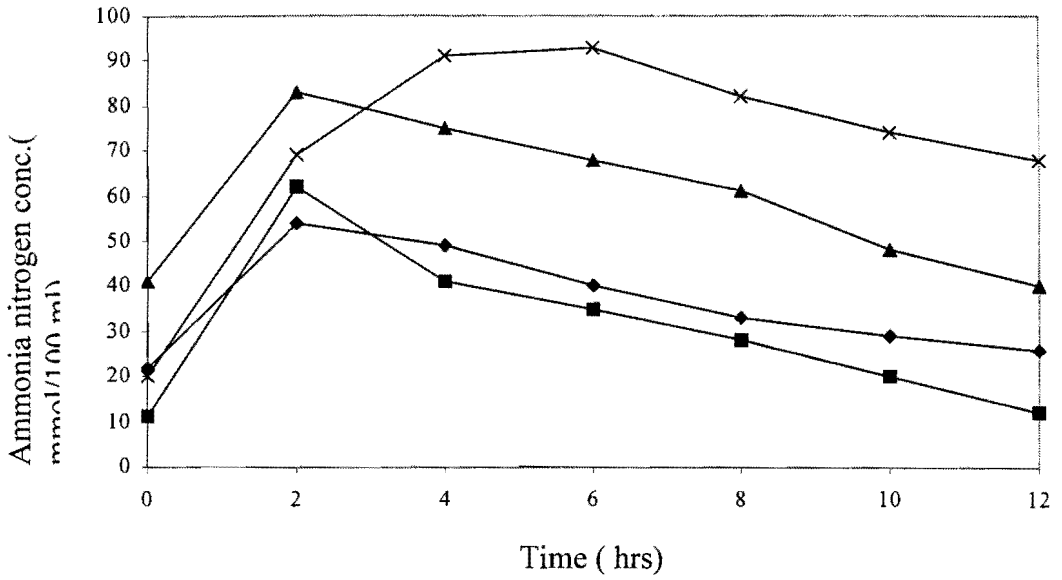


Figure 6.2: Rumen ammonia nitrogen concentrations in sheep fed concentrate and survival diets based on broiler litter: **0% litter (♦), 28% litter (■), 56% litter (▲), 85% litter (✕)**

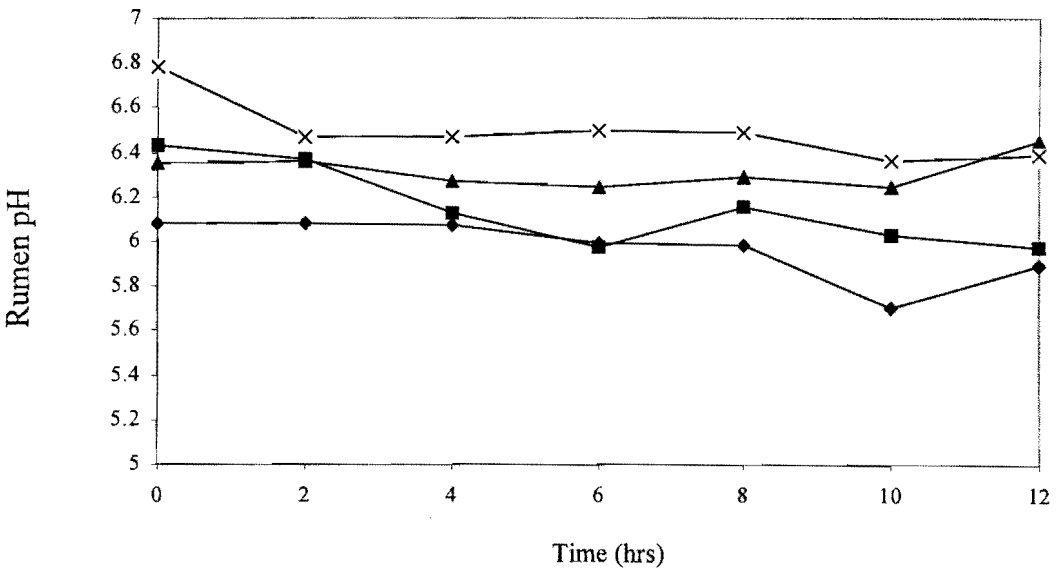


Figure 6.3 : Rumen pH in sheep fed various levels of broiler litter diets

0% broiler litter (◆), 28% litter (■), 56% litter (▲), 85% litter (✕)

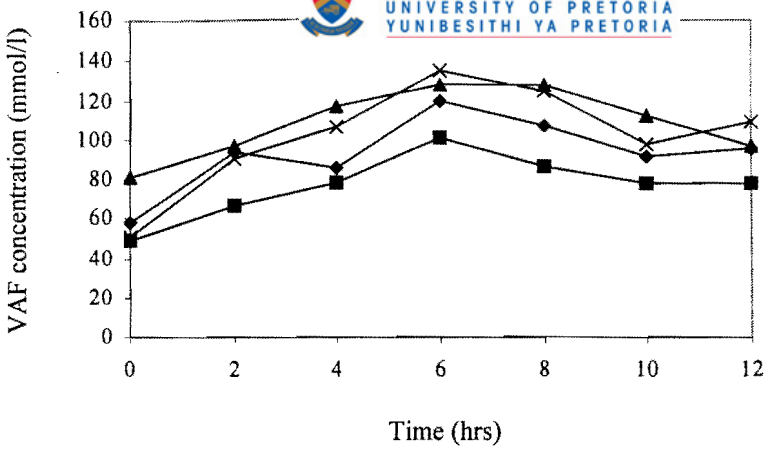


Figure 6.4 : Rumen VFA concentrations in sheep fed diets containing various broiler litter levels: **0% litter (◆), 28% litter (■), 56% litter (▲), 85% litter (✕)**

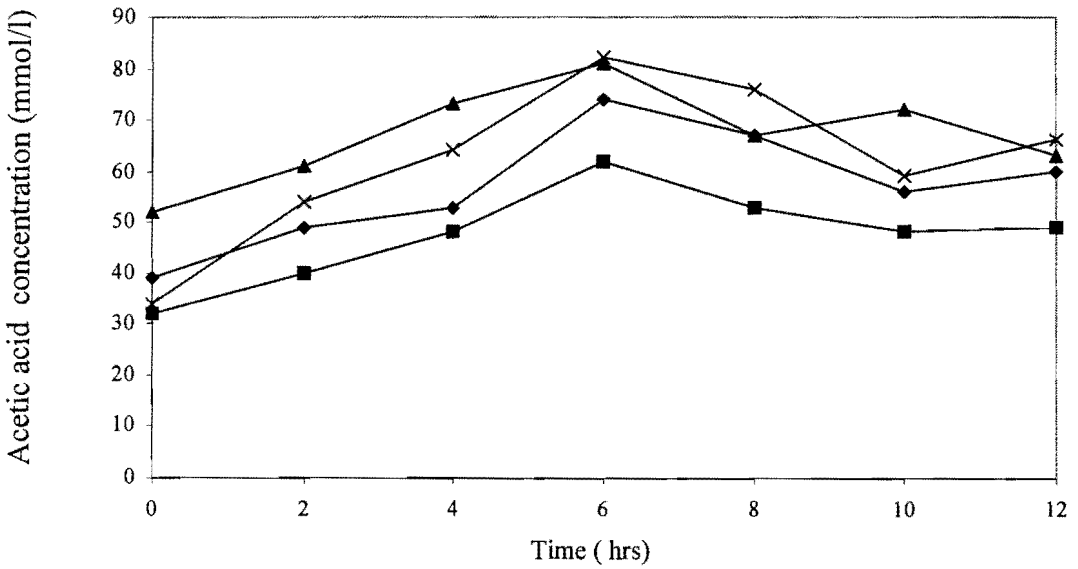


Figure 6.5 : Rumen acetic acid concentrations in sheep fed diets containing 0, 28, 56 and 85 percent litter diets: **0% litter (◆), 28% litter (■), 56% litter (▲), 85% litter (✕)**

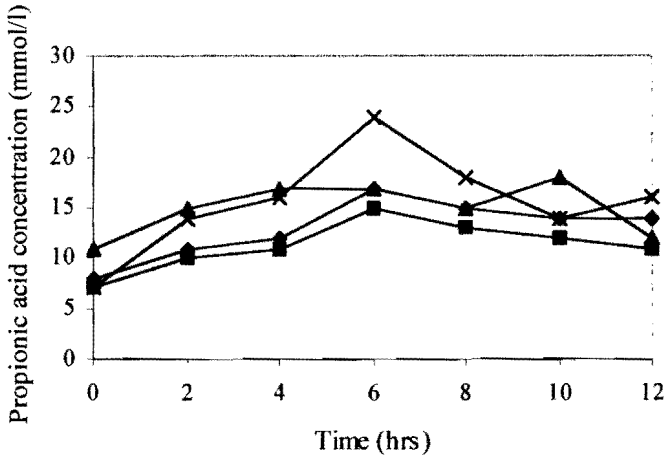
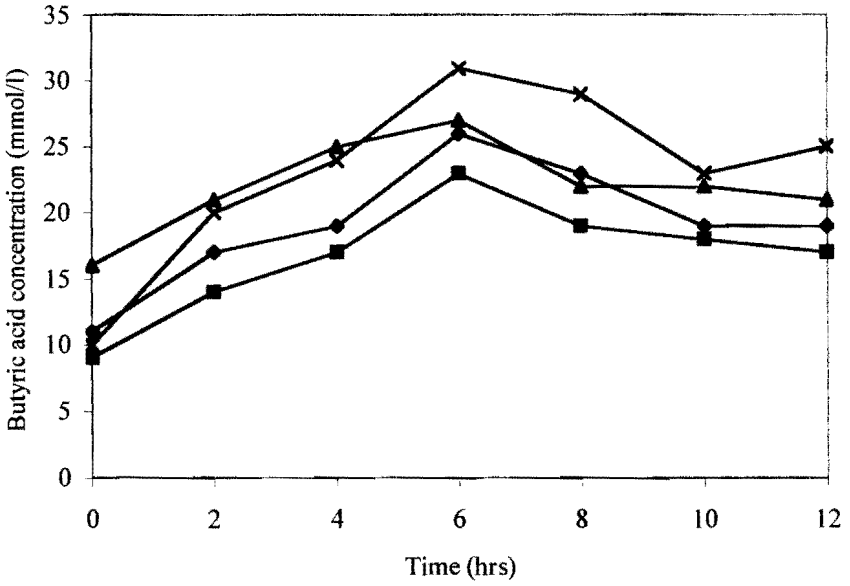


Figure 6.8 : Propionic acid concentrations in the rumens of sheep fed concentrate and survival diets based on broiler litter. 0% litter (◆), 28% litter (■), 56% litter (▲), 85% litter (✖)



Time (hrs)

re 6.7: Rumen butyric acid concentrations in sheep fed diets containing broiler litter at various levels. **0% litter (◆) 28% litter (■) 56% litter (▲) 85% litter (✕)**

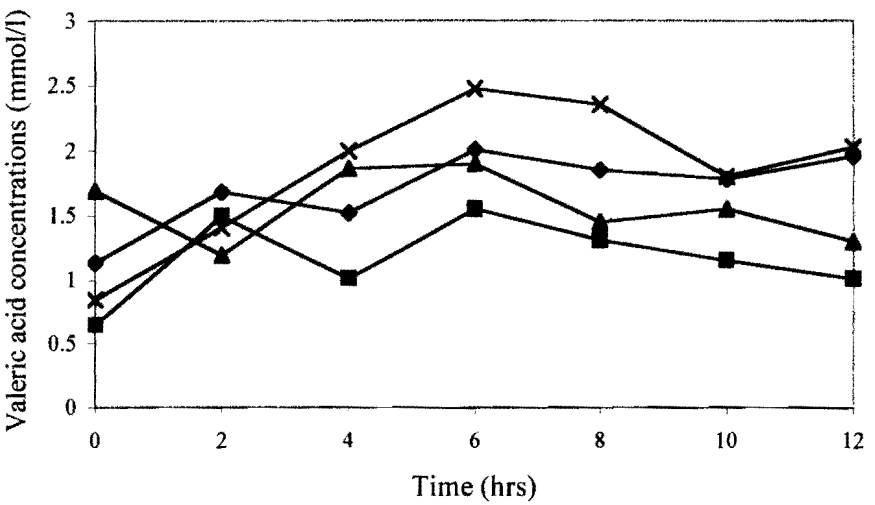


Figure 6.8: Rumen valeric acid production over a period of 12 hour by sheep fed broiler litter based diets: **0% litter (◆), 28% litter (■), 56% litter (▲), 85% litter (✕)**

6.4 DISCUSSION

Experiment 6.1

Up to inclusion of 56 percent broiler litter in the diet, weight gains and efficiency of feed conversions of the sheep were very similar. Bearing in mind that these wethers were two years of age, average daily gains of 0.160 to 0.176 kg could be considered as good. Smith & Calvert (1976) reported the best feed conversion in sheep when their diets contained 14 percent broiler litter, while Borgioli & Tocchini (1969) observed the highest daily weight gains from a diet containing 25 percent poultry litter. Likewise, Tagari *et al.* (1976) found that feed intake of steers was higher on broiler litter containing diets but feed efficiency was impaired when the proportion of litter exceeded 25 percent. Pelleting had a beneficial effect in terms of higher digestibility of crude protein and organic matter when a diet containing 40 percent litter was fed to calves, compared to lower litter inclusion rates (Kumanov *et al.*, 1969). Kargaard & Van Niekerk (1977) and Hadjipanayiotou (1984) reported that high levels of poultry excreta inclusion in high energy diets tended to depress animal performance. They attributed the depressed performance to the dilution of the energy content of the diets due to a low metabolisable energy value of poultry excreta. Whether the inclusion of broiler litter in a finishing diet of sheep or steers will affect the performance of the animals will obviously depend on the available energy value of the broiler litter relative to that of the rest of the diet. Broiler litter is quoted to have a low metabolisable energy value of 9.13 MJ/kg DM (Bhatacharya & Fontenot, 1966). This is probably low relative to an energy source such as maize meal. The Total Digestible Nutrient (TDN) content of the litter (+ 15% molasses) should be close to 60 percent that of organic matter (Table 6.3). This is lower than the TDN content of maize

meal of 75 percent (Bredon *et al.*, 1987), but probably not what could be described as low in available energy. Therefore, a lower weight gain can be expected if litter replaces a high energy concentration such as maize meal in a finishing diet. Financial considerations will thus determine whether it will be economical to include the litter in a finishing diet or not.

During the first 37 days of the trial the sheep on the 85 percent litter diet put on very little weight and consumed less of their diet than the other groups. However, both feed intake and average daily gain improved dramatically during the second 37 days to be comparable to those of the other treatments. Although less pronounced, this same trend was evident for the 56 percent litter group. The average daily gains of 0.168 kg in the 85 percent litter group during the second 37 days was better ($p < 0.05$) than the gains of 0.147 and 0.100 measured in the 0 and 28 percent litter groups respectively. However, it must be accepted that the sheep were probably in different stages of finishing, and compensatory growth might have played a role in the high weight gain in the high litter treatment.

The lack of growth of the sheep on the 85 percent litter diet during the first 37 days of the trial and the rapid growth there-after, suggest that rumen microorganisms required quite a long period to adapt to the high broiler litter diet, much longer than the 15 to 20 days that is normally accepted. It seems as if this observation is supported by the observation in the first trial (Chapter 2) where an initial low rumen microbial growth was estimated based on urinal purine concentrations of the sheep on the high broiler litter diets. If that is the

case, abnormal and incorrect measurements of digestibility and ruminal flow rates would be obtained if the period of adaptation was insufficient.

Considerable evidence has shown that a large proportion of an animal's maintenance energy requirements can be attributed to the visceral organs especially the liver and the digestive tract (Ferrel & Jenkins, 1985; Fluharty & McClure, 1997). The metabolic activity of the visceral organs is a function of the metabolic activity and size of the organ which is affected by level of nutrition (Fluharty & McClure, 1997). In the present study the liver and kidney weights of the sheep on the high litter diets were higher than those on the other diets. Weights of the different sections of the digestive tract did not differ among treatments, except for the abomasum. It can be speculated that this was due to the soil in the abomasums of the sheep on the high litter diets. One of the mechanisms which helps an animal to survive in a drought situation, is the reduction in visceral organ weights and thus in maintenance energy requirements (Fluharty & McClure, 1997). Heavier visceral organs as measured in the present study with the sheep on the high litter diets are therefore contrary to what should be aimed for under drought feeding conditions. This suggests that, under drought feeding conditions, it may be advisable to restrict broiler litter intake and thus reduce maintenance energy requirements.

The soil contamination of the broiler litter was probably the result of mechanical collecting of the litter. This is clearly an undesirable state of affairs and a risk that is run when unregistered broiler litter is fed to ruminants. As such, it would probably not have serious consequences to the animal.

Based on the activity of the plasma enzymes measured, no abnormal tissue catabolism has taken place in the sheep's bodies in any of the treatments. This supports the results obtained in the first trial (Chapter 2).

Experiment 6.2

The different crude protein concentrations of the experimental diets restrict direct comparison between diets. Rumen ammonia nitrogen concentrations for all diets were high, well above the optimum required for rumen microbial growth of between 2 and 20 mmol / 100 ml (Ørskov & Miller, 1988). It emphasizes that it would be wasteful to feed high levels of litter under drought feeding conditions because of the extra drain on energy in the body to detoxify the ammonia (Silanikove & Tiomkin, 1992). The ruminal ammonia nitrogen concentrations of the sheep that received the diets containing urea (control and 28 percent litter) peaked within two hours after feeding, while those on the 85 percent litter diet peaked at 4 to 6 hours after feeding. This probably supports the slower rate of degradation of other sources of nitrogen versus urea.

Over the 12 hours from feeding time the magnitude of ruminal pH (Figure 6.3) changes was small for the 56 and 85 percent litter diets compared to the control and 28 percent litter diets. The pH levels for the 56 and 85 percent litter treatments remained well above pH 6.00, reflecting the alkaline nature of broiler litter (Harmon *et al.*, 1974; Silanikove *et al.*, 1987) and its high buffering capacity. The pH values for the 56 and 85 percent litter diets are in agreement with those reported 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 present investigation. The control and 28 percent litter treatments showed pH reductions down to below pH 6.00 but higher than pH 5.5 at 6 hours from feeding. The introduction of 1 kg of feed directly into the rumen of the sheep would be less than what a sheep of 60 kg would consume voluntary per day. However, the rumen content pH should not be different from when *ad libitum* feed intake was allowed. This should be especially applicable for the finishing diets, the Control and 28 percent litter treatments.

Total VFA (Figure 6.4) peak concentrations were reached 6 hours from feeding time. The 85 percent litter diet recorded the highest concentrations followed by the 56 percent litter diet. In the present study, although not so pronounced, the pH negatively related to the VFA production. The proportion of individual VFA as on a molar percent basis compare well with those reported by Caswell *et al.* (1974) and Rossi *et al.* (1996) for diets containing lower levels of broiler litter. It may be noted that acetic acid (Figure 6.5) concentration for the 56 percent litter diet is higher than that of the other treatment diets in the first 6 hours from feeding time and is about the same as that of the 85 percent litter diet after 6 hours from feeding time. Propionic acid (Figure 6.6) concentrations show the same trend in the first 4 hours from feeding, thereafter, propionic acid concentration for the 85 percent litter diet is higher compared to other treatment diets. The difference between the 56 and 85 percent litter diets composition is that the 56 percent litter diet contains hay and maize meal. This may imply that the broiler litter used in this trial had enough energy in the form of chicken feed. The higher acetic acid production by sheep on

the 56 percent litter treatment compared to other treatment diets may be due to the inclusion of hay in the diet. Butyric acid (Figure 6.7) and valeric acid (Figure 6.8) concentrations showed the same trends as for acetic and propionic acid concentrations. It may be noted though that the control diet valeric acid concentration peaked at a higher concentration compared to the 56 percent diet and remained higher than that of the 56 percent litter diet over the remaining time to 12 hours.

6.5 CONCLUSIONS

This investigation demonstrated that broiler litter can be used in diets for sheep at levels above the recommended 25 percent. However, increasing the litter levels in the diets should be weighed against the desired time to slaughter as the inclusion of broiler litter may increase the adaptation time of the sheep to the feed. Feeding of broiler litter did not have any adverse effects on rumen conditions even when it was fed at very high levels. Because of its high nitrogen content, the inclusion of broiler litter in sheep diets may result in heavier livers and kidneys because of the increased ammonia burden on these organs. Silt content of the litter may result in an increase in the size of the abomasum as it tends to accumulate in this organ. However, the effect of silt in the litter remains to be tested.