CHAPTER 7

7.0 SENSORY CHARACTERISTICS OF MEAT AND SUBCUTANEOUS FAT COMPOSITION OF SHEEP FED DIFFERENT LEVELS OF BROILER LITTER

7.1 Introduction

In South Africa strict legislative control exists over the trading with litter as an animal feed. However, it does not preclude the farmer from feeding litter produced by himself or obtained as a fertiliser, to his livestock. During periods of feed shortage high levels of litter are sometimes fed (Chapter 2). In such emergency situations, farmers are often desperate to reduce stock numbers on the farm. Consequently, cattle and sheep which were fed high levels of poultry litter may end up in the abattoir and in the human food chain. The presence of drug residues in the litter which may contaminate the meat seems to be minimal, provided certain precautionary measures have been taken e.g. ensuring that the poultry did not receive any antibiotics or by enforcing a 15 day withdrawal period from the litter containing diet before slaughter (Fontenot, 1991). Taste panels could not detect any sensory effect in the meat of steers consuming diets containing up to 50% broiler litter (Fontenot *et al.*, 197; Smith *et al.*, 1979; Ben-Ghedalia *et al.*, 1988).

The composition of the ruminant diet may influence the flavour (Melton, 1990; Shand *et al.*, 1998) and fatty acid composition (Webb *et al.*, 1994 ; Shand *et al.*, 1998) of red meat. High energy grain diets were found to produce a more intense flavour in red meats than in low energy diets (Shand *et al.*, 1998). The composition of fatty acid in meat affects the taste of meat (Webb *et al.*, 1992; Shand *et al.*, 1998). Offer & Offer (1994) associated the reduction in the degree of saturation of tissue and milk fat to the feeding of distillery by-products. Similarly, changes in the fatty acid composition of both bovine and ovine tissues were attributed to components in the diet and the end-products in the digestive tract originating from them (Mills *et al.*, 1992; Rule *et al.*, 1994; Webb *et al.*, 1994b). The effect on carcass properties has not been investigated when very high levels of litter, typical that of an emergency drought feeding situation, were fed to ruminants. In the present study the sensory characteristics and fatty acid composition of mutton were studied when broiler litter constituted up to 85 percent of the sheep's diet.

7.2 MATERIALS AND METHODS

7.2.1 Animals and Treatments

Thirty six SA Mutton Merino wethers, *ca.* 18 months of age with an initial weight of 41 kg, were randomly allocated to four dietary treatments, viz. diets containing 0, 28, 56 or 85 percent broiler litter (Table 6.1). Sun-dried broiler litter was sifted and wethers vaccinated and dewormed as described in Chapter 6. The diets were fed as indicated in Chapter 6 and sheep had free access to water. Feed intake was recorded daily. The sheep were weighed at two week intervals. Wethers were slaughtered at 55 kg body weight to eliminate fatness as a factor in observed difference in sensory characteristics. On reaching a target weight of at least 55 kg the wethers were slaughtered by exsanguination and severing the spinal cord. Carcasses were electrically stimulated (21 V, 60 Hz, 120 sec.) and chilled overnight (4^0C) before samples were collected.

Subcutaneous fat was sampled (5g) from the left side of each carcass, at a point over the 13^{th} rib, 25 mm from the midline (Webb *et al.*, 1994b) and stored in a polyethylene bag at -20^0C, pending fatty acid analyses (Webb, 1992; Casey *et al.*, 1988). A three-rib sample was cut from the left side at ribs 8, 9 and 10 for dissection and estimation of the carcass composition. The ventral extremity of the sample was on a line drawn from the pubic symphysis to the middle of the first rib (Webb *et al.* 1994b).

7.2.2 Sensory evaluation

The left loin (M. *Longissimus thoracis et. Lumborum*) was removed from each carcass, vacuum packed and stored at -20^0C pending sensory evaluation. A trained sensory panel evaluated these samples on a 10 cm unstructured scale for aroma, juiciness, tenderness flavour and overall acceptability (Webb *et al.*, 1994b). Taint, fat to muscle ratio and fat firmness of the loins were measured according to the techniques described by Webb *et al.* (1994b). The panel used mutton and lamb as standard samples.

7.2.3 Chemical analysis

Extraction of lipids was done according to the procedure described by Ways & Hanahan (1964) as modified by Webb *et al.* (1994a). Methyl esters of the fatty acid component were prepared according to the NaOH / methanol method (A.O.A.C., 1975). The fatty acids were separated on a polar phase SP2330 column (2m x 3mm, packed with Silar 10c coated on Gas chrom Q) fitted to a Varian 3700 gas chromatograph with a flame ionisation detector (Webb *et al.,* 1994a). The DM, organic matter and crude protein concentrations in feed were obtained using standards A.O.A.C. (1990) procedures.

Neutral detergent fibre and acid detergent fibre concentrations in the diets were determined as described in Chapter 2.

7.2.4 Statistical analysis

Data emanating from laboratory analysis and panel testing were subjected to multifactor analysis of variance and detected by Duncan's multiple range test using the General Linear Models (GLM) procedure of SAS (SAS Institute, 1992).

7.3 RESULTS

Chemical composition of the feed and average daily feed intakes per sheep are reported in Tables 6.2 and 6.3. Wethers on the 85 percent broiler litter treatment required 155 days to reach the target slaughter weight compared to the 106, 112 and 115 days required by the 0, 28 and 56 percent litter treatment groups, respectively.

Carcass mass, carcass composition, dressing percentage and subcutaneous fat thickness did not differ significantly ($p < 0.05$) among treatments (Table 7.1). Subcutaneous fat thickness was 2.22, 2.47, 3.26 and 2.84 mm for the 0, 28, 56 and 85 percent litter diets, respectively. The fatty acid composition of the subcutaneous fat of the wethers is presented in Table 7.2. Significant differences ($p < 0.03$) were observed for myristic acid (C 14:0) which was recorded at 2.97, 2.58, 2.26 and 2.38 percent and margaric acid (C 17:0) ($p < 0.04$) at 2.136, 2.356, 2.081 and 1.914 percent for the control, 28, 56 and 85 percent litter diets, respectively. Differences between treatment diets ($p < 0.0001$) were also observed when linolenic acid (C 18:3) results were considered. Linolenic acid concentrations were 3.296, 3.117, 3.107 and 4.658 percent for the control, 28, 56 and 85 percent litter diets, respectively.

Sensory score results are presented in Table 7.3. Juiciness, tenderness, flavour and overall acceptability showed significant differences ($p < 0.05$) between treatment. Firmness, fat : muscle ratio and taint of the loin scores are found in Table 7.4. Significant differences in fat firmness ($p < 0.05$) were noted between treatment groups. Fat firmness tended to decline with increasing litter in the diet. Fat : muscle ratio was recorded at 56, 22, 22, and 22 for the control, 28, 56 and 85 percent litter treatment groups, respectively. An atypical taint was observed when mutton from sheep fed the 85 percent litter diet was tasted.

Table 7.1: Dressing percentage, carcass mass and carcass composition of mutton from wethers fed broiler litter based diets

	--------------------**Broiler litter (%)**--------------			
Parameters	**0**	**28**	**56**	**85**
Dressing (%)	48±2	49 ± 3	48 ± 6	47 ± 4
Carcass mass (kg)	26 ±3	27 ± 5	26 ± 7	25 ± 4
Carcass composition (9-10-11th rib cut)				
% lean	43 ± 0.8	46 ± 0.82	45 ± 0.83	45 ± 1.05
% fat	33 ±1.9	30 ± 0.75	32 ± 1.5	32 ± 1.63
% bone	24 ±3.2	24 ± 0.39	23 ± 0.65	23 ± 0.71
Subcutaneous fat thickness (mm)	2.22	2.47	3.26	2.84

Table 7.2: Influence of different levels of broiler litter diets on subcutaneous fat composition (molar %) of wethers

	--------------------Broiler litter (%)--------------------				
Fatty acid	**0**	**28**	**56**	**85**	**Significance**
C 14:0	3.0^{a}	2.6^{ab}	2.3^{b}	2.4^{b}	P = 0.03
C 15:0	0.28	0.36	0.27	0.36	NS
C 16:0	25.1	25.2	26.2	25.8	NS
C 16:1	2.6	2.9	2.7	2.6	NS
C 17:0	2.1^{ab}	2.4^{a}	2.1^{ab}	1.9^{b}	P = 0.04
C 18:0	20.0	18.4	18.0	18.5	NS
C 18:1	42.4	43.9	44.2	42.2	NS
C 18:3	3.3^{a}	3.1^{a}	3.1^{a}	4.7^{b}	P = 0.0001
C 20:1	1.2	1.3	1.2	1.6	NS

*Means on the same row with different superscripts are different

Table 7.3: Sensory characteristics of carcass samples from wethers fed high broiler litter levels

	---------------Boiler litter (%)--------------------			
Parameters	**0**	**28**	**56**	**85**
Aroma intensity	7.61 ± 0.46	7.58 ± 0.38	7.52 ± 0.57	7.41 ± 0.52
Juiciness	$7.78^{a} \pm 0.50$	$7.66^{a} \pm 0.56$	$7.58^{a} \pm 0.65$	$7.24^{b} \pm 0.60$
Tenderness	$7.48^{ab} \pm 0.67$	$7.61^{a} \pm 0.71$	$7.70^{a} \pm 0.78$	$7.27^{b} \pm 0.93$
Flavour	$7.71^{a} \pm 0.43$	$7.64^{a} \pm 0.45$	$7.58^{ab} \pm 0.45$	$7.45^{b} \pm 0.52$
Overall acceptability	$7.65^{a} \pm 0.44$	$7.61^{a} \pm 0.53$	$7.55^{a} \pm 0.59$	$7.23^{b} \pm 0.57$

*Means on the same row with different superscripts are different at $p < 0.05$
Scale : 0 - 10

Table 7.4: Loin sample characteristics of wethers fed different levels of broiler litter

Parameters	Broiler litter (%) 0	28	56	85
Fat firmness (%)				
Firm	89^a	67^b	67^b	78^c
Soft	11	33	33	22
Fat : muscle ratio (%)				
Little	56^a	22^b	22^b	22^b
Medium	44	67	78	56
Abundant	0	11	0	22
Taint (%)				
Typical	100	100	100	93.7
Atypical	0	0	0	6.3

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

7.4 DISCUSSION

Carcass mass, carcass composition, dressing percentage and subcutaneous fat thickness did not differ among treatments. Since all sheep were slaughtered at reaching 55 kg body weight, this had the advantage that the degree of fatness could be excluded as a reason for differences in the sensory characteristics due to diet composition. Fatty acid composition of the subcutaneous fat of the wethers was negatively affected by the litter inclusion. Inclusion of broiler litter in the diets reduced myristic acid (C 14:0) concentration from 2.97 mol (%) in the control to 2.38 mol (%) in the 85 percent litter treatment. Similarly, the margaric acid (C 17:0) was lower and the linolenic acid (C 18:3) concentration higher in the carcass fat of the wethers consuming 85 percent broiler litter diet, compared to the other treatment groups. It is well established that composition of the diet can change the fatty acid composition of the ruminant tissues (Mills *et al.*, 1992; Rule *et al.*, 1997; Webb *et al.*, 1994b). This has been attributed to the effect of the diet on changes in proportion and peak concentrations of volatile fatty acids produced in the rumen (Duncan *et al.*, 1974). High sensory scores (7 on a scale of 1 to 10) were obtained for all treatments. These corresponded well with sensory scores obtained for wethers finished on normal feedlot diets (Webb *et al.*, 1994b; 1997). Aroma intensity did not differ among treatments but tended to decrease with increasing inclusion of litter in the diets. The juiciness score of the loin samples from wethers fed the 85 percent litter diet was lower than the scores in other treatments. Ilian *et al.* (1988) recorded juicier meat when sheep received up to 40 percent poultry litter in their diets compared to the meat of sheep receiving no litter. However, increased juiciness was associated with an increased carcass fat content (Ilian *et al.*, 1988). In the present study carcass fat content did not differ among treatments and therefore could not have contributed to a decreased juiciness with the increase in litter inclusion in the diets.

The tenderness of *M. longissimus thoracis* samples from sheep on the 85 percent litter diet was lower ($p < 0.05$) than those of sheep on the 28 and 56 percent litter diets but did not differ from the control samples. Ilian *et al.* (1988) reported more tender meat when up to 40 percent poultry litter was included in diets of sheep than when no litter was included. Inclusion of 85 percent litter in the diet decreased the flavour of the sensory samples compared with the flavour in meat from the other diets. Webb *et al.* (1997) found that a higher proportion of carcass fat and a thicker subcutaneous fat depth were associated with lower flavour scores in the loin samples. They calculated that 31 percent of the variability in the flavour of the samples was due to the proportion of fat in the carcass. Again, fat thickness did not differ among treatments in the present study. However, this difference in flavour could be related to the lower proportions of the C 14:0 and C 17:0, and the higher proportion of C 18:3 fatty acids in the carcass fat of the 85 percent litter treatment compared to other treatments. Another factor, which is related to lower flavour scores, is a high level of arsenic in the diet (Westing *et al.*, 1985). Although the concentration of arsenic can be high in broiler litter (Westing *et al.*, 1985), arsenic concentrations were not measured in the diets used in the present study.

The overall acceptability of the loin samples tendered to decrease with increasing litter levels in the diets with an overall acceptability in the 85 percent litter treatment being lower then acceptability in the other treatments. A higher proportion of carcass fat and increased thickness of subcutaneous fat were found to be associated with a decline in overall acceptability of the loin samples (Webb *et al.*, 1997). Although in the present study the thickness of the subcutaneous fat tendered to increase with litter inclusion in the diets, these differences were not statistically significant. Furthermore, the degree of fatness was not related to type of diet, but rather to the fatness of the sheep at slaughter, which was done at a body weight of at least 55 kg.

The carcass of the wethers receiving the broiler litter diets tended to have lower fat firmness scores compared to the control diet. A decline in fat firmness scores was observed when wethers consumed high energy diets (11.8 MJ ME /kg DM) which is associated with a high propionic acid concentration in the ruminal fluid, compared to diets lower in energy concentration (10.2 MJ ME /kg DM) (Webb *et al.*, 1997). Likewise, processing of cereals which is associated with an increase in the proportion of propionic acid in the ruminal fluid was found to decrease the firmness of the subcutaneous fat in sheep (Ørskov *et al.*, 1974). In general, an increase in the broiler litter component of the diet tended to decrease the energy concentration of the diet. However, because the physical properties of litter which is a combination of the manure powder and coarse bedding material, the ratio of these component can vary. Consequently, the effect of litter inclusion in a diet on volatile fatty acid composition in the rumen seems to be inconsistent. Fontenot & Jurubescu (1980) and Rossi *et al.* (1996) reported that the inclusion of litter diets altered rumen fermentation towards increased propionic acid production. Such a change towards a higher propionic acid concentration in the ruminal fluid was not observed (Chapter 6) when diets high in litter were fed to sheep.

The taint of all meat from the 0, 28 and 56 percent broiler litter treatments was classified as “typical”, while 6.3 percent of the samples from the 85 percent litter diet was classified as “atypical”. The taint of these samples was described as “sour”. According to Melton (1990) and Shand *et al.* (1998) the composition of the ruminant diet may influence the flavour of red meat. Webb *et al.* (1994b) and Shand *et al.* (1998) observed that the composition of the ruminant diet also affected the subcutaneous fatty acid composition. The “atypical” taint observed in the study may be due to the composition of the litter, which had a higher mineral content. However, the magnitude and true cause of the flavour has to be confirmed in further studies.

From the present study it is concluded that the inclusion of broiler litter at levels of more than 56 percent might induce slight detrimental effects on the sensory quality of the meat. This seems to be mainly because of changes in the fatty acid composition of the carcass fat and an acquisition of an off flavour in the meat. However, in the event of an emergency feeding situation, mutton producers could include up to 56 percent broiler litter in the diet without affecting the eating quality of the mutton.

CHAPTER 8

8.0 THE NUTRITIONAL VALUE OF BROILER LITTER AS A FEED SOURCE FOR SHEEP DURING PERIODS OF FEED SHORTAGE-

CONCLUSIONS

It must be accepted that most people will probably find the feeding of animal excreta to other animals revolting and offensive. An even worst reaction could be expected if it should be known that such a product is not registered as an animal feed. Such a reaction can be anticipated, considering the total ban in Europe on the feeding of animal products to other animals. However, any farmer watching his livestock waning away because of lack of food, be it during a protracted drought which is frequently occurring in Southern Africa or the result of veld fires that destroyed vast areas of grassland, would be desperate to help his animals and would resort to desperate means of achieving that. Farmers' financial resources would seldom be adequate to simply buy in feedstuffs, which usually have to be transported over long distances, thus adding to their cost. The feeding of poultry manure during such periods of food shortage is therefore both a humane act towards the animal and an attempt of the farmer to survive financially. This present investigation was therefore not intended to disprove the concerns of opponents to the feeding of poultry excreta to animals, nor to justify the feeding of unregistered poultry manure to ruminants. The objective was to evaluate the effects on the animal of feeding high levels of broiler litter as an emergency nutrient resource and to be able to advise farmers on the safe use of broiler litter under these conditions. The hypothesis was that broiler litter could be fed successfully to overcome such a crisis situation, provided certain basic precautions are taken.

In the study, the feeding and management practices on the farm during a drought were followed as far as possible. The broiler litter was not sterilised but sun-dried, usually containing a moisture content of less than 15 percent. The product was sifted to remove lumps and dead chickens and the animals were vaccinated twice against botulism, at five and one weeks before the starting of a trial. It is accepted without further verification that the botulism toxin is frequently present in broiler litter and that the animals must be vaccinated. The litter in different trials was obtained from different sources, therefore representing litter from a variety of broiler production enterprises. In most of the trials a maximum voluntary intake of the litter was allowed in an attempt to solicit a worst possible response or reaction in the sheep.

The sun-dried broiler litter available in South Africa is usually low in moisture (< 12%) and according to Weuthrich (1979) a medium unsuitable for microbial growth. Therefore, a basic requirement if unsterilised litter is used as a survival feed, is that the litter must be dry and be kept dry. The dry Southern African climate with its abundance of sunshine has probably the advantage that the litter used by farmers is usually dry, probably containing few if any pathogens. This may explain why farmers in Southern Africa who are feeding broiler litter to their livestock usually experience minimal destinct problems related to pathogens. Based on plasma enzyme activities and the histopathological evaluation of tissues, no evidence of tissue damage or a health problem in the sheep could be related to their high broiler litter intakes in the present study. Despite these observations, plenty of evidence and an active field of research, mainly in the USA, demonstrated that there are different cheap methods of sterilizing poultry litter for animal consumption. These include the ensiling of litter with other crops or alone, deep stacking, etc. (Carter &Poore, 1998).

The nitrogen concentration of Southern Africa litter seems to be low compared to similar products in the USA and other countries. Fontenot & Jurubescu, (1980) reported a crude protein concentration of 300 g/kg DM for USA litter. Compared to that the average South African samples contain ±200 g /kg DM (Van Ryssen *et al.*, 1977 and present study). This difference could be due to the method of drying the litter. Sun-drying could result in a substantial loss of ammonia causing the low crude protein in South African samples. Furthermore, the local practice of keeping birds on bedding material for only one production cycle before the house is cleaned, compared to five to six cycles in the USA would reduce the proportion of manure to bedding material and thus the crude protein concentration in the local material.

Despite the relatively low crude protein concentration in the litter used in the present study, very high concentrations of ammonia in the rumen fluid (51.4 mmol/100ml) and urea in the blood (293 mg/l) were recorded in the sheep consuming the litter. Results from the partial digestion study showed that as much as 50 percent of the nitrogen in the pure litter diets did not reach the abomasum of the sheep, and was apparently lost through the rumen wall. Such high blood urea and ammonia concentrations could be harmful to animals in terms of fertility and production (Polmann et al., 1981; Erb et al., 1976; Jordan & Swanson, 1979). No immediate detrimental effect on the sheep was recorded in the present study. A high concentration of ammonia was expected in the rumen. This prompted the decision to add molasses to some experimental diets to encourage a more efficient microbial conversion of the ammonia to protein in the rumen. However, the addition of molasses increased the rate of passage of the ingesta through the rumen, making it impossible to measure the effect of molasses *per se* on protein synthesis by the microorganisms in the rumen. Despite the higher rate of flow with the addition of molasses, the total quantity of nitrogen lost from the rumen was approximately the same, with or without the addition of molasses. The risks associated with high ammonia concentrations in the rumen and body with the feeding of high levels of litter could therefore not be eleviated through the inclusion of molasses to the diet. At a restricted litter plus 15 percent molasses intake, the response might have been different. However, this was unfortunately not tested in the study.

From this study it appears as if the uric acid concentration in the South African litter is very low. This may indicate a possible loss of ammonia during sun-drying. It would be interesting to verify this observation on local litter samples in a more extensive survey.

The available energy in broiler litter is claimed to be low (Bhattacharya & Fontenot, 1966; Bhattacharya & Taylor, 1975; Bull & Reid, 1971; Tinnimit *et al*., 1972). However, although the ME is not as high as a pure energy source such as maize meal, the quoted values of 10.21 MJ ME / kg DM are not low, nor the digestibility of the organic matter measured in the present study. Therefore, it may be questioned if the addition of 15 percent molasses to litter could have substantially improved the supply of available energy to rumen microbes. It could only be speculated why the addition of 15 percent molasses increased the dry matter intake as observed in the present study. Even more relevant is the question of whether the addition of the 15 percent molasses was benefitial or not to the animal in a survival feeding situation. The addition of molasses resulted in a drastic increase in feed intake, though did not reduce the demand on the energy resources in the body to metabolize the surplus ammonia absorbed from the rumen. Furthermore, the high feed intake resulted in an increase in weight of visceral organs, and thus in energy requirements to sustain these heavier tissues. It is suggested that the intake of broiler litter in a survival feeding situation should be restricted and molasses should be added only if litter intake is unsatisfactorily low. The sheep consuming the litter at a rate of 1.9 % of their body weight, still gained weight. This suggests that litter consumption for survival does not have to be more than approximately 1.5 percent of body weight.

With the addition of 15 percent molasses a change in the site of disappearance of organic matter towards the lower digestive tract was recorded. Whether the animal is benefiting at all from that is not certain, though, under drought feeding conditions, does not seem to be desirable. This again supported the suggestion that the addition of molasses is not required in a survival ration.

From the two growth trials it was clear that broiler litter even at a 100 percent litter diet contained enough energy to give weight gains and improved body condition of the sheep. This may be an added bonus under survival feeding conditions if the farmer can sell his animals. However, since there is no guarantee that there are no drug residues present in the litter, such a practice of introducing these animals into the human food consumption chain cannot be recommended.

World-wide, pressure is on animal feed manufacturing companies to produce animal feeds that are environmentally friendly, i.e. resulting in the lowest possible excretion of substances that can pollute the environment. This is to the advantage of the livestock producer using broiler litter because potential drug and mineral residues in litter would be less of a problem. In South Africa, copper sulphate and the coccidiostat, highly toxic to ruminants, maduramicin, are not included in broiler diets and therefore not a problem when the litter is fed to ruminants. A potential problem of litter as a feed for ruminants is the high calcium and phosphorus concentrations. Phosphorus can precipitate urinary calculi in sheep, and the calcium can be a problem causing milk fever in beef cows. The feeding of broiler litter to pregnant beef cows close to calving therefore cannot be recommended. Selenium in broiler litter is readily bio-available, making broiler litter a good source of selenium. Iron concentrations in broiler litter are well above the requirements for ruminants, posing a potential problem of iron toxicity.

In the present investigation it appeared as if the sheep consuming high levels of broiler litter took a long time to adapt to the diet. It is not clear if that was due to a slow adaptation of rumen microorganisms to broiler litter diet or for some other reason. This will obviously not be desirable in a survival feeding situation, nor in experiments where a statistical design such as a Latin square is used. Further studies are required to clarify this.

Broiler litter consists of a mixture of faeces, litter material and sometimes apparently soil. Soil contamination of the litter was evident in one batch of litter used, though its effect on the animal and production seems to be relatively small (Brosh *et al.*, 1998). However, it would be advisable to ensure that soil contamination is restricted to a minimum because of its diluting effect on the litter and the tendency of the soil to accumulate in the rumen and abomasum. The local litter is coarser than the USA product, probably explaining the absence of bloat in South African livestock on high levels of litter compared to the USA situation.

It can be concluded that broiler litter can be used successfully as a survival diet for ruminants. However, it was clear that there are potential health problems to the animal and certain precautions must be taken. Results in this study suggested that it may be desirable to feed to litter at a level well below optimal intake. A level of approximately 1.5 percent body weight is suggested.