Effects of chicory on sensory carcass quality in lambs

Final report

May 2010

SAC project: 56020021

Jos Houdijk
Nutrition and Health, Disease Systems Team, SAC
West Mains Road, Edinburgh EH9 3JG
email: jos.houdijk@sac.ac.uk

Contents

Sections	Page
Executive summary	3
Background and Objectives	4
Methodology	4
Results	7
Discussion and Conclusion	13
Acknowledgement	13
References	14

Executive summary

Lambs grazing chicory grow faster, and thus finish earlier, and usually have lower levels of parasitism. However, little is known about whether finishing lambs on chicory will affect carcass quality. Over two seasons (Year 1 and Year 2), the killing out percentage, carcass grading and loin sensory quality of a total of 110 lambs (49 grass/clover lambs and 61 chicory lambs) were assessed. Sensory quality was assessed at the taste panel facilities at Bristol University.

Chicory lambs had consistently higher killing out percentage compared to grass lambs with similar carcass fat scores and higher carcass conformation scores (during Year 2 only) and without detrimental effects on loin sensory quality. In contrast, during Year 1, when male (wether) and female lambs were tested in different panels, there were indications that grazing chicory may result in increased juiciness and less grassy flavour in female lambs only. This effect on juiciness was not confirmed during Year 2, where sex effects were tested within panels. However, during Year 2, chicory lambs had higher lamb flavour, whilst female chicory lambs scored again as less grassy but also tended to score less fatty/greasy compared to their grass/clover raised counterparts. In addition, none of these sensory scores used correlated with final faecal egg counts, suggesting that any effect of chicory on sensory quality of loins in lambs is unlikely to be mediated through its effect on parasitism.

More research is needed to verify the positive effects of chicory on selected sensory qualities observed in parts of this study (e.g. enhanced lamb flavour and reduced fatty/greasy flavour). However, we can conclude that using chicory as an alternative crop for finishing lambs can be expected to yield higher carcass weights at similar or better grades without detrimental effects on meat sensory eating quality.

Background and Objective

There is a growing body of evidence that lambs grazing chicory grow faster, and thus finish earlier in the season, and have lower levels of parasitism. Recent studies are demonstrating these benefits during both the pre- and post weaning period (Athanasiadou et al., 2007; Kidane et al., 2008). Driven by the practical benefits and fuelled by articles in the popular press, there is considerable increased uptake of chicory by the farming community for finishing lambs. For example, in Scotland, chicory seed sales in 2008 and 2009 have already increased by 300% relative to 2007. However, little is known about whether finishing lambs on chicory will affect carcass quality, although it can be expected from the more rapid growth that carcasses may be leaner when market weights are reached, compared to finishing more slowly on grass.

The objective of this work was to assess killing out percentage, carcass grade and sensory meat quality of loins from lambs reared on chicory or grass/clover.

Methodology

Lambs, soil and forage details. Wether and female lambs were drawn from experimental work (Year 1, 2008, Suffolk x Mule; n=50) and a commercial farm (Year 2, 2009, Texel x Mule; n=60), and were either reared on chicory or on grass/clover. The chicory fields used were sown and grazed the year prior to the study years, and consisted of a pure stand during Year 1, and a chicory/plantain mixture during Year 2 (commercial mixture with predominantly chicory). Grass/clover mixtures had ~5% clover. Soils could be characterised as sandy-loam (Year 1) and light gravely sand (Year 2). Detailed forage nutritional quality is available for Year 1 only. Compared to grass/clover, chicory had significantly lower dry matter contents (111 vs 220 g/kg), but its dry matter was significantly higher in crude protein (229 vs 90 g/kg), ash (106 vs 55 g/kg), crude fat (46 vs 27 g/kg) but lower in NDF (270 vs 419) and ADF (211 vs 244). *In vitro* digestibility was similar at ~81%, resulting in a higher estimated ME content for chicory compared to grass/clover per kg dry matter (12.6 vs 12.0 MJ ME). The concentration of most macro-minerals and trace elements analysed was more than twice as high in chicory than in grass/clover, including Ca, Na, Mg, K, P, S, Zn, Cu and Fe. Forage heights ranged from 10 to 25 cm for grass/clover, and from 10 to 35 cm for chicory. Due to experimental constraints, lambs were set-stocked at 10 per acre during Year 1. However, under commercial conditions during Year 2, stocking

density varied between 3 and 12 per acre, with small periods of up to 24 per acre to get on top of bolting chicory during May 2009.

Loin samples. Lambs were slaughtered at a designated slaughterhouse (ScotBeef, Bridge of Allan, UK), where excellent traceability ensures proper recording of individual lamb carcass identification and weights to obtain killing out percentages, carcass grading and to retrieve the loins for meat quality assessment through a taste panel at University of Bristol. Loins were retrieved after hip suspension for 24 h at ~2°C at the slaughterhouse. Loins were then matured for another 9 days at SAC at ~2°C, before frozen pending analysis in Bristol. Lamb final live weight and carcass weights were used to calculate killing out percentage.

Sensory analysis. Loins were transported frozen to Bristol and there stored at -20°C until sensory assessment. The loins were thawed overnight and then de-boned on the morning of sensory assessment. Each loin was cut into 2cm thick loin steaks; 8 to 10 sections were cut from each loin. Loin samples were cooked (turning every 3 minutes) under a domestic grill set at high, until the internal temperature of each sample reached 75 °C as measured by a thermocouple probe. The samples were then removed from the grill and placed in an incubator (60 ºC) prior to sampling. The lean was trimmed of all extraneous residual fat and connective tissue, before being wrapped separately in pre-coded (3-digit numbers) aluminium foil and placed in hot blocks in each sensory booth. Assessors who had been screened according to British Standards Institute methods for taste sensitivity and who had also received special training in the assessment of meat took part in the tests. All tests were completed under red light to reduce potential bias that could arise from differences in appearance.

Assessors were asked to rate 8 point category scales for: tenderness, juiciness, lamb flavour intensity, abnormal lamb flavour intensity and also two hedonic scales for flavour liking and overall liking. In addition, a thirteen descriptor flavour profile, using unstructured 100 mm intensity scales, was also used, where 0 = nil intensity and 100 =extreme intensity. Each tasting booth was equipped with computer terminals linked to a fileserver running a sensory software programme (Fizz v 2.20h, Biosystemes, Couternon, France) that facilitated the direct entry of assessor ratings.

Lamb performance and faecal egg counts. Birth body weight and date (recorded individually during Year 1, and estimated at 4.75 kg during Year 2 with

birth over a few days around 10 April 2009), and body weight just before slaughter were used to estimate mean growth rates and days to slaughter. Carcass grading was visually assessed according to EUROP scale for conformation score, and 1, 2, 3L or 3H for fat score. Final faecal egg counts just before slaughter were assessed during Year 1 through FEC was measured according to a modified floatation method (Christie and Jackson, 1982) using polyallomer centrifuge tubes to collect the nematode eggs from the meniscus. The sensitivity of this method is 1 egg per gram of faeces.

***Statistical analysis*.** During Year 1, lambs were allocated to different sub-panels according to sex, to account for sex-effects on lamb sensory quality, and as far as possible for other the other factor arising from the experimental design during Year 1 (i.e. level of maternal protein supplementation). In Year 2, panels were balanced as much as possible for the factors sex and diet. Due to the great differences in finishing weights and weather between years 1 and 2, results are reported for each year separately. In addition, the experimental design used during the sensory assessment did not allow pooling the data, as in Year 1 panel is nested within sex, whilst during Year 2 this was not the case.

Reported results for Year 1 were derived from a REML analysis of variance where forage treatment was used as the only factor for each sex of lamb, whilst panel was included as random effect. The other factor balanced for during Year 1, i.e. level of maternal protein nutrition, did not significantly affect the sensory quality parameters measured. Reported results for Year 2 were also derived from a REML analysis of variance where forage treatment and sex were used as the factors, whilst again panel was included as random effect. Results for both years are reported as predicted means from REML, and accompanied by the S.E.D. In addition, full P-values of effects are provided. In the tables, significant P-values are printed in bold, and trends are printed in bold italic.

Performance data and carcass grades are analysed through GLM for effects of chicory vs grass/clover, and are presented with min-max range between brackets after each results, combined with S.E.D. and P-value where appropriate. Carcass grades were analysed following transformation into scores, with E=1, U=2, R=3, O=4 and P=5 for the conformation grades, and 1=1, 2=2, 3L=3 and 3H=4 for the fat grades.

Results

Year 1. Due to adverse weather conditions, experimental work in 2008 had to be stopped earlier than planned, and the number of lambs slaughtered was consequently less than planned, and at lower weight and grade than under commercial standards (see below, Year 2). In addition, because chicory lambs grow faster than grass/clover lambs, the consequence was that the number of replicates in the chicory group was larger than in the grass/clover group (31 vs 19).

Mean days to slaughter for those slaughtered averaged 177 (162-197) days for chicory lambs and 182 (163-198) days for grass/clover lambs (S.E.D. 3.1; P=0.11). At slaughter, chicory and grass/clover lambs weighed 39.1 (30.9-50.0) and 36.4 (31.5-45.5) kg, respectively (S.E.D. 1.35 kg; P=0.051), which they reached at a mean growth rate of 197 (158-257) and 176 (156-210) g/day, respectively (S.E.D. 6.6 g/day; P=0.002). Their killing out percentages were 39.9 (35.5-45.3) and 37.2 (31.2-51.7) %, respectively (S.E.D. 1.00; P=0.01). Carcass grades did not differ, and averaged for conformation score at 4.2 (3-5) and fat score at 2.1 (1-4), or an averaged grade of O2.

The results of the sensory assessments are summarized in Tables 1.1 (female lambs) and 1.2 (wether lambs). The data suggest that loins of chicory reared female lambs were juicier compared to those from grass reared lambs with a tendency for a reduced “grassy” flavour (Table 1.1). In some sub-panels, this effect on juiciness was highly significant (5.3 vs 4.7; P<0.01) whilst female chicory lambs tended to score higher values for tenderness (5.5 vs 5.0; P=0.077) and for higher ‘livery’ flavour (11.2 vs 3.9; P=0.050). However, the latter effects were not significant in the whole dataset.

The positive effect of chicory on loin juiciness in female lambs was not observed in wether lambs. In fact, the differences observed on the wether loin sensory quality were limited to a decreased ‘kidney’ flavour (7.8 vs 15.0; P<0.05) and a tendency for a decreased bitterness (2.2 vs 5.3; P=0.08) in chicory fed wether lambs compared to grass fed wether lambs in some sub-panels, but this was not apparent in the whole dataset (Table 1.2). Importantly, for both wether and female carcasses, flavour and overall liking did not differ.

Table 1.1: Sensory loin quality of female lambs on chicory or grass/clover (Year 1).

	Chicory (n=10)	Grass/clover (n=8)	s.e.d.	P-value
8 point category scale used				
Texture	5.5	5.2	0.25	0.333
Juiciness	5.2	4.9	0.14	**0.025**
Lamb flavour	4.2	4.4	0.30	0.494
Abnormal flavour	2.4	2.0	0.28	0.176
Hedonic				
Flavour liking	5.1	5.2	0.29	0.793
Overall liking	5.1	5.1	0.27	0.991
1100mm line scale used				
Fatty/Greasy	13.9	14.6	2.24	0.751
Livery	11.2	7.2	3.01	0.207
Kidney	11.1	10.0	3.02	0.722
Sweet	8.3	8.6	2.05	0.894
Acidic	6.6	4.0	2.03	0.215
Metallic	8.9	10.3	2.72	0.621
Bitter	4.1	4.9	1.87	0.684
Rancid	0.7	0.5	0.55	0.655
Ammonia	1.1	0.9	0.43	0.805
Grassy	6.2	10.6	2.37	***0.077***
Fishy	0.8	1.5	0.52	0.211
Soapy	5.6	4.8	1.61	0.634
Dairy	7.1	8.7	1.32	0.857

Table 1.2: Sensory loin quality of wether lambs on chicory or grass/clover (Year 1).

	Chicory (n=21)	Grass/clover (n=11)	s.e.d.	P-value
8 point category scale used				
Texture	5.2	5.5	0.20	0.148
Juiciness	5.0	4.9	0.14	0.591
Lamb flavour	4.1	4.2	0.19	0.828
Abnormal flavour	2.5	2.4	0.15	0.777
Hedonic				
Flavour liking	4.8	4.8	0.19	0.907
Overall liking	4.7	4.7	0.20	0.856
1100mm line scale used				
Fatty/Greasy	13.4	12.1	2.73	0.630
Livery	9.9	10.5	1.88	0.739
Kidney	10.6	12.9	1.86	0.224
Sweet	8.1	7.7	1.14	0.692
Acidic	6.7	4.2	1.65	0.134
Metallic	12.2	12.5	1.91	0.898
Bitter	3.1	4.4	1.26	0.280
Rancid	2.8	1.1	1.63	0.312
Ammonia	1.5	1.8	0.47	0.434
Grassy	9.9	9.1	1.64	0.626
Fishy	1.2	0.5	0.42	0.135
Soapy	4.4	5.2	1.01	0.417
Dairy	6.3	6.7	1.35	0.761

Year 2. Mean days to slaughter was 193 days during Year 2. Chicory and grass/clover lambs weighed 46.9 (42.0-50.0) and 45.1 (41.0-49.0) kg, respectively (S.E.D. 0.53 kg; P<0.001), which they achieved at mean growth rates of 219 (193-234) and 209 (188-229) g/day, respectively (S.E.D. 2.7 g/day; P<0.001). Their killing out percentages were 46.8 (43.0-49.3) and 44.6 (39.1-52.0) %, respectively (S.E.D. 0.55%; P<0.001), respectively. Carcass grades did not differ for fat score, averaging at 2.7±0.06 (2-4), but chicory carcasses had lower (better) conformation score than grass/clover lambs, averaging at 2.2 (2-3) and 2.6 (2-3), respectively (S.E.D. 0.12; P=0.003). Thus, chicory and grass/clover lambs had an averaged carcass grading of U3L and R3L, respectively.

The results of the sensory assessments are summarized in Table 2. The only significant main effect of chicory was observed for lamb flavour, where chicory loins were scored as having a higher lamb flavour than grass/clover lambs. However, there were trends of interactions between feed and sex for fatty/greasy flavour, acidic flavour and grassy flavour, where in female lambs only chicory feeding reduced grassy and fatty/greasy flavour whilst it increased for acidic flavour. Significant main sex effects were observed; texture, abnormal flavour and kidney flavour were scored lower for wether lambs than for female lambs, whilst sweet and soapy flavour were scored higher in wether lambs than in female lambs. Importantly, as in Year 1 data, flavour and overall liking did not differ.

Table 2: Sensory loin quality of wether (W) and female (F) lambs on chicory or grass/clover (Year 2).

	Chicory		Grass/clover			P-values		
	W (n=18)	F (n=12)	W (n=16)	F (n=14)	s.e.d.	Feed	Sex	FxS
8 point category scale used								
Texture	5.7	6.1	5.8	6.1	0.20	0.728	**0.016**	0.523
Juiciness	5.1	5.1	5.0	5.1	0.14	0.618	0.436	0.529
Lamb flavour	4.7	4.7	4.5	4.4	0.11	**0.002**	0.395	0.876
Abnormal flavour	2.3	2.4	2.2	2.5	0.11	0.487	**0.019**	0.287
Hedonic								
Flavour liking	5.3	5.2	5.2	5.1	0.12	0.434	0.112	0.692
Overall liking	5.2	5.1	5.2	5.1	0.12	0.959	0.217	0.663
1100mm line scale used								
Fatty/Greasy	12.2	9.7	11.1	11.1	1.12	0.899	0.112	***0.095***
Livery	7.9	9.0	8.5	9.0	1.13	0.627	0.344	0.693
Kidney	7.3	9.6	6.1	8.4	1.12	0.143	**0.004**	0.979
Sweet	14.0	12.6	13.6	12.3	1.14	0.545	***0.099***	0.545
Acidic	3.2	4.0	3.5	3.2	0.51	0.624	0.478	***0.090***
Metallic	5.1	5.5	5.1	5.1	0.68	0.768	0.628	0.633
Bitter	2.8	3.1	2.5	2.8	0.70	0.515	0.579	0.978
Rancid	0.8	0.4	0.4	0.7	0.31	0.643	0.702	0.138
Ammonia	3.3	3.8	3.0	3.3	0.44	0.208	0.201	0.635
Grassy	5.9	5.6	5.8	6.6	0.42	0.186	0.381	***0.067***
Fishy	3.3	3.1	3.6	3.5	0.44	0.191	0.726	0.897
Soapy	4.0	3.4	3.9	3.8	0.33	0.706	***0.080***	0.311
Dairy	11.9	10.7	11.3	9.8	1.25	0.358	0.117	0.870

Year 1 and 2 combined. The results of the sensory assessments of Year 1 and 2 combined are summarized in Table 3, with main effects for feed, year and interactions provided.

Table 3: Effect of forage (chicory vs grass/clover) and year (Year 1 vs 2) on sensory lamb loin quality.

	Chicory		Grass/clover			P-values		
	Year 1 (n=31)	Year 2 (n=30)	Year 1 (n=19)	Year 2 (n=30)	s.e.d.	Feed	Year	FxY
8 point category scale used								
Texture	5.3	5.9	5.4	5.9	0.16	0.558	**0.001**	0.867
Juiciness	5.1	5.1	4.9	5.0	0.11	0.113	0.226	0.297
Lamb flavour	4.2	4.7	4.2	4.4	0.13	0.305	**0.001**	**0.037**
Abnormal flavour	2.4	2.4	2.3	2.3	0.12	0.183	0.714	0.359
Hedonic								
Flavour liking	4.9	5.2	5.0	5.2	0.13	0.987	**0.003**	0.423
Overall liking	4.8	5.2	4.9	5.2	0.13	0.734	**0.001**	0.740
1100mm line scale used								
Fatty/Greasy	13.6	11.2	13.1	11.1	1.43	0.800	**0.020**	0.862
Livery	10.3	8.4	9.1	8.7	1.26	0.707	0.119	0.360
Kidney	10.7	8.2	11.7	7.1	1.34	0.815	**0.001**	0.244
Sweet	8.2	13.4	8.0	13.0	0.98	0.596	**0.001**	0.811
Acidic	6.8	3.5	4.0	3.3	0.96	**0.013**	**0.004**	**0.013**
Metallic	11.1	5.3	11.7	5.1	1.23	0.814	**0.001**	0.620
Bitter	3.4	2.9	4.6	2.6	0.81	0.487	***0.065***	0.144
Rancid	2.1	0.6	0.9	0.5	0.75	0.234	**0.025**	0.259
Ammonia	1.4	3.5	1.4	3.1	0.34	0.467	**0.001**	0.300
Grassy	8.7	5.8	9.7	6.1	1.00	0.300	**0.001**	0.602
Fishy	1.1	3.2	0.9	3.6	0.34	0.465	**0.001**	0.222
Soapy	4.8	3.8	5.0	3.9	0.62	0.680	**0.016**	0.813
Dairy	6.5	11.4	6.8	10.6	0.99	0.598	**0.001**	0.444

Concerning the main effect of forage treatment, none of the earlier referred to forage effects on sensory quality was significant in the pooled data set; the statistically strongest effect observed was that chicory reared lambs were scored juicier than grass/clover lambs but this just failed to approach a statistically accepted tendency

(P= 0.11). Confirming the individual Year 1 and Year 2 data, overall flavour and overall liking scores did not differ. Concerning the main effect of year, loins assessed during Year 2 were more tender, sweeter, with higher ammonia, fishy and dairy scores and in general higher overall liking and flavour liking scores compared to loins from Year 1, whilst the fatty/greasy, kidney, metallic, bitter, rancid, grassy and soapy scores were lower. Only one significant interaction was observed; loins were scored as having a higher acidic flavour for lambs in chicory during Year 1 only.

Correlations with terminal faecal egg counts. Table 4 shows the correlations between the log-transformed faecal egg count taken just before slaughter and the sensory parameters measured. Out of the 19 correlations calculated, only ammonia flavour correlated significantly and negatively (r=-0.30; P<0.05) with terminal faecal egg counts, whilst there were trends for such negative correlation with tenderness (r=-0.24; P=0.10) and livery (r=-0.26; P=0.08).

Table 4. Correlations between log-transformed final faecal egg count (tFEC) and sensory loin quality

	tFEC	P-value
Texture	-0.24	***0.103***
Juiciness	0.06	0.700
Lamb flavour	-0.08	0.570
Abnormal flavour	0.09	0.529
Flavour liking	-0.05	0.726
Overall liking	-0.05	0.711
Fatty/Greasy	0.16	0.287
Livery	-0.26	***0.079***
Kidney	-0.21	0.143
Sweet	0.09	0.526
Acidic	0.16	0.270
Metallic	-0.07	0.624
Bitter	-0.20	0.168
Rancid	-0.01	0.958
Ammonia	-0.30	**0.037**
Grassy	-0.04	0.773
Fishy	0.15	0.321
Soapy	0.08	0.591
Dairy	-0.03	0.863

Discussion and conclusion

The main benefits arising from this work would be a demonstration that the use of chicory as an alternative crop to finish lambs does not negatively affect lamb carcass quality. Data from both years, judged individually as well as combined, are indeed showing that grazing on chicory does not negatively affect carcass quality. The increased juiciness during Year 1, observed in female lambs only, was challenged during Year 2 of the study through allocating samples to the taste panels balanced for sex and diet. The absence effects on juiciness during Year 2, including the absence of an interaction between feed and sex, strongly suggest that the effects observed in Year 1 on juiciness may have been a chance finding, although it can not be excluded that such effects on juiciness are attributable to the fact that lambs were lighter in Year 1. Similarly, during Year 2 only, chicory lambs were scored as having a higher lamb flavour. Although it can not be excluded that this may also have been chance findings, confidence in Year 2 results may be greater, since the Year 2 data set was more balanced than Year 1, and samples for Year 2 were drawn from animals finished under commercial conditions and good weather conditions.

Because of the relatively large number of correlations calculated, caution is needed to not overemphasise the fact that one correlation was significant and two were showing trends. However, taken as a whole, these three correlations were negative, suggesting that the higher the last faecal egg count, the lower the scores for these attributes. It is of interest that one of these correlations is tenderness, suggesting a possible link between level of parasitism at slaughter and sensory carcass quality. However, more data is needed to substantiate this view.

In conclusion, using chicory as an alternative crop for finishing lambs can be expected to yield higher carcass weights with similar or better carcass grades and with no detrimental effects on meat sensory eating quality.

Acknowledgements

With the risk of overlooking anybody, thanks goes to Alex Moir of SAC Farm for supplying the lambs for Year 1 and Ray Field of Lilburn Estate Farming Partnership for supplying the lambs for Year 2, SAC colleagues Elly Navajas, Dave Ross, Bert Tolkamp, Kirsty McLean, John Gordon, Scot Gray, Clare Anderson, Laura Nicoll, Dave Anderson, Terry McHale, Alem Kidane, Anouk Veldhuis (visiting

student) and Zoi Parissi (visiting scientist) for their assistance in obtaining lamb production data, organising the logistics around getting the lambs to the slaughterhouse and retrieving the loins, Suzie England, Murray Hardy, Gerard McCafferty, Phil Craig and Karol Wojcik of the ScotBeef slaughterhouse for allowing us access to their slaughterline to monitor the slaughter and retrieve the samples, Courier Express Refrigerated Transport Ltd for transporting the frozen loins to Bristol, and Geoff Nute, Ian Richardson and Ann Baker of Bristol University for carrying out the sensory assessments.

EBLEX, HCC, QMS and LMC funded loin retrieval and sensory assessment; ScotBeef provided carcass weights and grades; Scottish Government (Rural and Environment Research and Analysis Directorate), with support from a MLC studentship, funded the experiment during Year 1 to obtain production data reported (adapted from Kidane et al (2009a) and Kidane et al (2009b)).

References

Athanasiadou, S., Gray, D., Younie, D., Tzamaloukas, O., Jackson, F. and Kyriazakis, I (2007). The use of chicory for parasite control in organic ewes and their lambs. *Parasitology* **134**: 299-307.

Christie, M. and Jackson, F. (1982). Specific identification of strongyle eggs in small samples of sheep faeces. *Research in Veterinary Science* **32**: 113-117.

Kidane, A., Athanasiadou, S., Houdijk, J.G.M., Tolkamp, B.J. and Kyriazakis, I. (2008). The interactive effects of maternal nutrition and subsequent grazing on bioactive forage on lamb performance and parasitic status. *Proceedings of the British Society of Animal Science*: 97.

Kidane, A., Houdijk, J.G.M., Athanasiadou, S., Tolkamp, B.J. and Kyriazakis, I. (2009a). Consequences of ewe protein nutrition and grazing on chicory (*Cichorium intybus*) on animal performance and parasitism. *Proceedings of the 22st International Conference of the World Association for the Advancement of Veterinary Parasitology*; p. 16.

Kidane A., Parissi, Z., Houdijk, J.G.M., Athanasiadou, S., Tolkamp, B.J. and Kyriazakis, I. (2009b). Chicory (*Cichorium intybus*) as promising bioactive forage for sheep production. In: *Alternative Functions of Grassland*. *Proceedings of 14th European Grassland Federation Symposium*, B. Cagaš, R. Macháč, J. Nedělník (eds). pp. 394-397.