THE EFFECT OF DIFFERENT INCLUSION LEVELS OF DIATOMACEOUS EARTH IN FEEDLOT DIETS ON THE PERFORMANCE OF LAMBS

A.T. Nkwana[1,2], J.H. Hoon[1#] & P.J. Fourie[2]
[1] Grootfontein Agricultural Development Institute, Private Bag X529, Middelburg (EC), 5900
[2] Department of Agriculture, Central University of Technology, Private Bag X20539, Bloemfontein, 9300
[#]E-mail: JanHo@daff.gov.za

INTRODUCTION

Diatomaceous earth (DE), also known as diatomite, is a naturally occurring, silicon-rich sedimentary rock made up of fossilised remains of millions of diatoms, a type of hard-shelled plant algae originally deposited millions of years ago in the earth from dried up seas and lakes. DE is primarily amorphous silica, while it also contains sodium, magnesium, iron and trace elements such as selenium and copper (Köster, 2010). Four distinct uses for food grade DE in livestock and poultry production have been reported, namely insect and parasite control, mineralisation, absorption, and grain protection. DE has been recognised as an organic product for animal health and nutrition and is claimed to be an effective growth promoter and alternative natural anthelmintic for sheep, goats and other livestock (Köster, 2010). There is, however, a general lack of scientific literature to support its use in animal health and nutrition (Schoenian, 2013).

Different theories have been postulated on the mode of action of DE in the improvement of animal health and production. With regard to the control of parasites, one theory states that because DE has small, sharp edges, its abrasive action scratches off the waterproof coating of the insects and absorbs lipids from the waxy outer layer of their exoskeletons, causing them to dehydrate and die. Another theory is that DE acts as a buffer in the stomach, thereby creating an unsuitable environment for the feeding and reproduction of the parasites (Köster, 2010). With regard to gains in production, the most probable reason is the assumed effect of DE in the reduction of the parasite population, resulting in decreased stress on the animal and increased food assimilation. The mineral contribution of DE might also play a role in improved production, as it contains a broad spectrum of naturally occurring minerals. The properties that DE possesses in improving the absorption of other minerals, in particular the effect of silicon on improved overall mineralisation (e.g. bone), could furthermore be a possible reason for enhanced animal performance (Köster, 2010).

Numerous testimonies by farmers, veterinarians and others are available on observations made in their operations with DE. In an on-farm lamb feedlot study with lambs, feed conversion rate (FCR) was improved by 5% and 11% and overall profitability per lamb was in favour of the groups with 1% and 2%

DE respectively, above the control group (Köster, 2010). Deutschlander (1993) reported that lambs fed with DE showed faster weight gain, “cleaner tails” and “brighter wool”, while the overall body condition also improved. McLean et al. (2005) reported that cattle and sheep that received a DE supplement had low faecal egg count (FEC) for the duration of the experimental period, similar to animals supplied with an anthelmintic. In a study with goats by Gregory et al (2009), DE did not show any significant effects on the parasite loads but significant differences in body weight among treatments were observed, with the lowest dosage of DE showing the highest weight gain. No significant differences in the FCR, average daily gain (ADG), dry matter intake and days on feed between the control and DE groups were found in a study with feedlot beef steers (Fernandez et al., 1998). In a study by Osweiler & Carson (1997) with grazing lambs fed DE at 5 and 10% of a supplemental ration, no significant difference in weight gains, haemoglobin, packed cell volume, FEC and abomasal gastro-intestinal larval counts were found in control vs. DE-fed lambs. In a review article, Whitley & Miller (2015) concluded that the majority of controlled studies with published results including sheep, goats and cattle, have noted no significant impact of DE products on gastro-intestinal nematode infection indicators.

It is essential to develop optimal feeding levels for DE in different species and for different applications through proper scientific studies. At this stage it appears that the levels generally used are between 0.5% and 2% of the total diet of animals (Köster, 2010). The aim of this study was to determine the effect of different levels of DE on the growth rate, carcass characteristics, eye muscle area, fat depth and FEC of lambs receiving feedlot diets.

MATERIALS AND METHODS

The project was conducted at Grootfontein Agricultural Development Institute (GADI) near Middelburg in the Eastern Cape Province. Fifty Ronderib Afrikaner x Merino lambs (37.2 kg ± 4.4) were used. The animals were divided on a stratified body weight and FEC basis into five groups of ten lambs each. The animals in all the groups were provided with the same feedlot diet (Table 1). DE was included at different levels as part of the diet. The groups consisted of one control and four treatment groups and the following DE inclusion levels were used: Treatment 0 (Control) = 0.0%, Treatment 1 = 0.5%, Treatment 2 = 1.0%, Treatment 3 = 1.5% and Treatment 4 = 2.0%.

Table 1. The composition of the feedlot diet before the addition of DE

Ingredients	Inclusion level (%)
Lucerne	50
Maize	38.1
Feed grade urea	0.5
Cotton oil cake meal	2.5
Molasses meal	8.0
Feed lime	0.6
Salt	0.3

Before the start of the project, faecal samples of all the animals were taken at 2-hour intervals between 8:00 and 16:00 for one day to determine the average FEC. The lambs were also weighed before the start of the project. The groups were placed in pens and adapted to the diets for 14 days before the data collection started. Body weights were recorded on a weekly basis and FEC on a two-weekly basis for the duration of the project. The eye muscle area (measured as the cross-sectional area of the *longissimus dorsi* muscle) and fat depth over the eye muscle area of the lambs were measured with an ultrasound scanner at the start and again at the end of the project just before slaughtering. All the lambs were slaughtered at the GADI abattoir after a 46-day feeding period (20 July to 04 September 2017). After slaughtering, warm and cold carcass weights, V1, V2 and V3 fat measurements, hind leg length, hind leg circumference, carcass length and abdominal fat weight were recorded (Bruwer & Naudé, 1987; Bruwer et al., 1987a; Bruwer et al., 1987b).

The General Linear Model (GLM) procedure of SAS was used to determine the effect of different DE inclusion levels in feedlot diets on the weekly body weights, body weight change from the start to the end of the project, ADG, FEC, eye muscle area, fat depth and carcass characteristics of the lambs (SAS, 2016).

RESULTS AND DISCUSSION

The average starting and end body weights, body weight change (BWC) and ADG of the lambs from the different groups are presented in Table 2. There were no differences ($P > 0.05$) among the different groups in terms of body weights, BWC and ADG. These results concur with those from a study by Osweiler & Carson (1997) where no significant differences were found in the weight gain of grazing lambs receiving a DE-supplemented feed compared to a control group (no DE). It is also in agreement with a study by Fernandez et al. (1998) with beef steers in a feedlot where no significant differences in the ADG of the DE and control groups were observed.

Table 2. Body weights (start and end), body weight change (BWC) and average daily gain (ADG) (± s.e.) of lambs from the different groups

Parameter	Treatment 0	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Start weight	37.8 ± 1.5	37.5 ± 1.4	37.4 ± 1.5	37.5 ± 1.4	37.5 ± 1.4
End weight	44.7 ± 1.7	45.3 ± 1.7	44.9 ± 1.7	45.7 ± 1.7	45.5 ± 1.7
BWC (kg)	6.9 ± 0.7	7.8 ± 0.7	7.5 ± 0.7	8.1 ± 0.7	8.0 ± 0.7
ADG (g)	150.2 ± 15.6	168.7 ± 15.0	162.8 ± 15.6	176.9 ± 15.0	174.1 ± 15.0

The eye muscle area (EMA) and fat depth (FD) measurements of the lambs from the different groups are presented in Table 3. No differences (*P* >0.05) in the EMA (start) and EMA (end) were observed among the groups. No differences (*P* >0.05) were also observed in FD (start) between the groups. FD (end) of Treatment 4 was higher (*P* <0.05) than Treatments 1 and 2, but did not differ from the other groups. For EMA change, no differences (*P* >0.05) were observed among the groups. However, FD change of Treatment 4 was higher (*P* <0.05) than Treatment 2, but did not differ from the other groups.

Table 3. Eye muscle area (EMA), fat depth (FD) and change in eye muscle area and fat depth (± s.e.) of lambs from the different groups

Parameter	Treatment 0	Treatment 1	Treatment 2	Treatment 3	Treatment 4
EMA start (cm^2)	8.41 ± 0.32	8.88 ± 0.30	8.71 ± 0.32	9.19 ± 0.31	9.17 ± 0.31
EMA end (cm^2)	10.39 ± 0.41	10.38 ± 0.39	10.53 ± 0.41	10.58 ± 0.39	10.69 ± 0.39
EMA change (cm^2)	1.99 ± 0.24	1.50 ± 0.22	1.82 ± 0.24	1.39 ± 0.23	1.52 ± 0.23
FD start (cm)	0.36 ± 0.03	0.36 ± 0.03	0.38 ± 0.03	0.39 ± 0.03	0.39 ± 0.03
FD end (cm)	0.61^{ab} ± 0.04	0.56^{b} ± 0.03	0.55^{b} ± 0.04	0.59^{ab} ± 0.03	0.68^{a} ± 0.03
FD change (cm)	0.24^{ab} ± 0.04	0.20^{ab} ± 0.04	0.17^{b} ± 0.04	0.20^{ab} ± 0.04	0.29^{a} ± 0.04

^{ab} Means with different superscripts in rows differ significantly (*P* <0.05)

The faecal egg counts (FEC) of the lambs from the different groups are presented in Table 4. As the lambs were divided into groups at the start of the project based on a stratified body weight and FEC basis, no differences (*P* >0.05) in roundworm counts (eggs per gram - EPG) were observed among the different groups at the first recording (EPG1). EPG2 also did not differ (*P* >0.05) from one another. With regard to EPG3, Treatment 0 and Treatment 1 differed (*P* <0.05) from Treatment 2 and Treatment 4, but did not differ (*P* >0.05) from Treatment 3. At the end of the project, EPG4 of Treatment 1 was higher (*P* <0.05) than Treatment 4, but did not differ from Treatment 0, Treatment 2 and Treatment 3. In general, there was a decline in the roundworm counts of the different groups, including the control group, from the start to the end of the project. A decline in roundworm counts is, however, generally a natural occurrence during the cold winter period.

With regard to coccidia counts (oocysts per gram - OPG), no differences (*P* >0.05) among the groups were observed at the start of the project (OPG1), as well as for the OPG2 counts. For OPG3, Treatment 2 was higher (*P* <0.05) than Treatment 0, but did not differ from the other groups. At the end of the project, OPG4 of Treatment 1 differed (*P* <0.05) from the other groups. In general, the coccidia counts of the groups increased from the start until the end of the project. An increase in coccidia counts is, however, generally a natural occurrence under intensive, penned conditions. The FEC results of this study concur with a study by Gregory et al (2009) with goats, which showed that DE did not have any significant effects on the internal parasite load of the animals. It is also in agreement with a study by Osweiler & Carson (1997) with grazing lambs fed DE in a supplemental ration where no significant difference in faecal egg/gram counts and abomasal gastro-intestinal larval counts were found in control vs. DE-fed lambs. Whitley & Miller (2015) also concluded that the majority of controlled studies with ruminant livestock showed no significant impact of DE on gastro-intestinal nematode infection indicators.

Table 4. Roundworm (EPG - eggs per gram) and coccidia (OPG - oocysts per gram) counts (± s.e.) of lambs from the different groups

Parameter	Treatment 0	Treatment 1	Treatment 2	Treatment 3	Treatment 4
EPG1	2043 ± 829	2117 ± 798	2058 ± 829	2038 ± 798	1946 ± 798
EPG2	1065 ± 326	818 ± 326	800 ± 326	1388 ± 314	857 ± 355
EPG3	1413^{a} ± 204	1121^{a} ± 187	460^{b} ± 194	913^{ab} ± 186	538^{b} ± 186
EPG4	770^{ab} ± 169	933^{a} ± 162	453^{ab} ± 169	708^{ab} ± 162	325^{b} ± 162
OPG1	195 ± 105	371 ± 101	160 ± 105	108 ± 101	121 ± 101
OPG2	303 ± 149	580 ± 149	408 ± 149	408 ± 143	377 ± 162
OPG3	350^{a} ± 299	746^{ab} ± 273	1458^{b} ± 283	663^{ab} ± 273	796^{ab} ± 273
OPG4	355^{a} ± 367	2358^{b} ± 353	1133^{a} ± 367	283^{a} ± 353	238^{a} ± 353

^{ab} Means with different superscripts in rows differ significantly (*P* <0.05)

The carcass measurements of the lambs from the different groups are presented in Table 5. The slaughter weight, warm and cold carcass weight, carcass yield, carcass length, hind leg length and hind leg circumference did not differ (*P* >0.05) among the different groups.

Table 5. Carcass measurements (± s.e.) of lambs from the different groups

Parameter	Treatment 0	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Slaughter weight (kg)	44.7 ± 1.7	44.5 ± 1.6	44.9 ± 1.7	46.3 ± 1.8	45.5 ± 1.7
Warm carcass weight (kg)	21.5 ± 1.0	21.6 ± 0.9	21.2 ± 1.0	22.3 ± 1.0	22.1 ± 0.9
Cold carcass weight (kg)	21.1 ± 0.9	21.2 ± 0.9	20.8 ± 0.9	21.9 ± 1.0	21.7 ± 0.9
Carcass yield (%)	47.1 ± 0.6	47.4 ± 0.5	46.2 ± 0.6	47.4 ± 0.6	47.5 ± 0.5
Carcass length (cm)	111.5 ± 1.8	111.8 ± 1.6	113.8 ± 1.8	113.7 ± 1.8	112.2 ± 1.7
Hind leg length (cm)	51.9 ± 0.9	52.1 ± 0.8	52.2 ± 0.9	52.1 ± 0.9	51.5 ± 0.9
Hind leg circumference (cm)	66.3 ± 1.3	67.2 ± 1.1	66.7 ± 1.3	67.6 ± 1.3	67.0 ± 1.2

The fat measurements of the lambs from the different groups are presented in Table 6. The V1 and V2 fat measurements of Treatment 3 differed (P <0.05) from Treatment 2, but they did not differ from Treatment 0, Treatment 1 and Treatment 4. The V3 fat measurement did not differ (P >0.05) among the groups. The weight of the abdominal fat of the different treatments also did not differ (P >0.05) among the groups.

Table 6. Fat measurements (± s.e.) of lambs from the different groups

Parameter	Treatment 0	Treatment 1	Treatment 2	Treatment 3	Treatment 4
V1 fat (mm)	10.15^{a} ± 1.19	11.30^{a} ± 1.08	8.75^{ab} ± 1.19	12.92^{ac} ± 1.26	11.17^{a} ± 1.15
V2 fat (mm)	8.52^{a} ± 1.04	8.97^{a} ± 0.94	8.15^{ab} ± 1.04	11.58^{ac} ± 1.09	9.33^{a} ± 1.00
V3 fat (mm)	9.12 ± 1.09	9.70 ± 0.99	9.20 ± 1.09	11.17 ± 1.15	10.54 ± 1.05
Abdominal fat weight (kg)	1.28 ± 0.15	1.16 ± 0.13	1.27 ± 0.15	1.29 ± 0.16	1.28 ± 0.14

^{abc} Means with different superscripts in rows differ significantly (P <0.05)

CONCLUSION

In this study, the inclusion of DE at levels up to 2.0% in feedlot diets did not have a significant effect on the growth rate of the lambs. DE also did not significantly reduce parasite loads as measured by FEC. With regard to carcass characteristics, fat measurements, eye muscle area and fat depth, the inclusion of different levels of DE did not have a significant effect on most of these traits. Despite the widespread interest in using DE as a growth promoter and natural anthelmintic for livestock, the inclusion of different levels (0.5 to 2.0%) of DE in feedlot diets did not have a significant effect on the growth rate, carcass characteristics and FEC of lambs in this study.

ACKNOWLEDGEMENTS

The Central University of Technology (CUT), Bloemfontein, is acknowledged for financial support.

REFERENCES

Bruwer, G.G. & Naudè, R.T., 1987. An evaluation of the lamb and mutton carcass grading system in the Republic of South Africa. 3. Fatness score, conformation score and carcass mass as predictors of carcass composition. S. Afr. J. Anim. Sci. 17, 90-94.

Bruwer, G.G., Naudè, R.T., du Toit, M.M. & Cloete, A., 1987a. An evaluation of the lamb and mutton carcass grading system in the Republic of South Africa. 2. The use of fat measurements as predictors of carcass composition. S. Afr. J. Anim. Sci. 17, 85-90.

Bruwer, G.G., Grobler, I., Smit, M. & Naudè, R.T., 1987b. An evaluation of the lamb and mutton carcass grading system in the Republic of South Africa. 4. The influence of age, carcass mass and fatness on meat quality characteristics S. Afr. J. Anim. Sci. 17, 95-103.

Deutschlander, D., 1993. Evaluating diatomaceous earth as a wormer for sheep and cattle. In: Greenbook '93, p.37. Energy and Sustainable Agriculture Program, Minnesota Department of Agriculture, St. Paul, Minnesota, USA.

Fernandez, M.I., Woodward, B.W. & Stomberg, B.E., 1998. Effect of diatomaceous earth as an anthelmintic treatment on internal parasites and feedlot performance of beef steers. Animal Science 66, 635-642.

Gregory, B., Mulumebet, W. & Mohamed, A., 2009. The effects of diatomaceous earth on parasite infected goats. Bull. Georg. Natl. Acad. Sci. (3)1, 129-135.

Köster, H., 2010. Diatomite in animal feeds. Animate Animal Health. http://www.allaboutfeed.net/Home/General/2010/10/Diatoms-in-animal-feeds.

McLean, B., Frost, D., Evans, E., Clarke, A. & Griffiths, B., 2005. The inclusion of diatomaceous earth in the diet of grazing ruminants and its effect on gastrointestinal parasite burdens. In: International Scientific Conference on Organic Agriculture, Adelaide, Australia, 277-280.

Osweiler, G.D. & Carson, T.L., 1997. Evaluation of diatomaceous earth as an adjunct to sheep parasite control in organic farming. Leopold Center Completed Grant Reports, 102. http://lib.dr.iastate.edu/leopold_grantreports/102.

SAS Institute Inc., 2016. SAS OnlineDoc® 9.4 Procedures Guide, 6th edition. Cary, NC: SAS Institute Inc.

Schoenian, S., 2013. Diatomaceous earth: Is it an effective natural anthelmintic for sheep and goats? A review of the scientific literature. www.sheepandgoat.com/articles/DE.html.

Whitley, N.C. & Miller, J.E., 2015. Does diatomaceous earth have a role in worm control? Joint W4 Congress presented by: The Faculty of Veterinary Science, (FVS) South African Veterinary Association (SAVA) and American Consortium for Small Ruminant (ACSRPC), 25-26 May 2015, Pretoria.