*Short communication*

# *Megasphaera elsdenii* on the performance of steers adapting to a high-concentrate diet, using three or five transition diets

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## Abstract

*Megasphaera elsdenii (M.e.)* NCIMB 41125 is a robust lactate utilizing strain of *M.e.* that is effective in minimizing the risk of ruminal acidosis in feedlot cattle. When dosed orally, cattle adapt smoothly to increasing concentrates in the diet, the incidence of digestive disturbances, morbidity and mortality is reduced, and carcass yield improves. One could therefore expect that the smooth transition should benefit overall performance. Dosing with the organism also provides the opportunity of a reduction in the time necessary for adaptation, rendering a further decrease in the cost of feeding. These two objectives were tested with 80 yearling crossbred steers blocked by weight before allotment to the respective treatments. The trial design was a randomized 2 × 2 factorial of two drench treatments (*M.e.* vs. placebo) and two adaptation periods (17 vs. 8 days). In the *M.e.* treatment, 40 steers were dosed orally on day 1 of the trial with 200 mL inoculum containing $10^{11}$ cells. In the placebo treatment, the other 40 steers were dosed orally with only the 200 mL inoculum. In the 17-day transition period, five diets (5–transition) were used, which increased progressively in concentrate percentage, whereas in the 8-day transition period only three of the five diets were fed (3–transition). The steers were fed individually for 63 days before being transferred to group pens and fed until day 95, when they were slaughtered. Dry matter intake was not affected by dose or transition treatment. Body weight at 28 days and 63 days did not differ between dose and transition treatments; neither did ADG and FCR. Hot carcass weight was higher in *M.e.* steers than in placebo steers. None of the parameters differed significantly between the 5–transition and the 3–transition treatments. It was concluded that dosing with *M.e.* NCIMB 41125 should provide a small benefit to performance of feedlot cattle, with a further benefit in cost savings as dosing with the organism should allow a shorter adaptation period.

**Keywords:** Steers, transition diets, feed intake, body weight, growth, growth, carcass characteristics
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Ruminal acidosis in feedlot cattle manifests when lactic acid accumulates rapidly and pH declines as a result. The condition usually occurs during transition from an all-roughage to a high-concentrate diet over a short time when the microbial population and the rumen environment have not adapted properly to the fermentation medium of primarily starches and sugars. To prevent the condition, lactic acid needs to be removed rapidly, in which the robust strain NCIMB 41125 of the lactic acid utilizing species *Megasphaera elsdenii* excels (Henning *et al.*, 2010a; Meissner *et al.*, 2010). The strain (hereafter referred to as *M.e.*) is dosed at the commencement of the adaptation phase and supports a smooth transition as observed, with a reduction in the number of digestive disturbances, treatments, morbidities and mortalities (Leeuw *et al.*, 2009; Meissner *et al.*, 2010). One would naturally expect that the health benefits would carry over to the total feeding period and reflect in improved performance. However, although milk production of the high-producing cow appears to benefit (Meissner *et al.*, 2010; Aikman *et al.*, 2011; Henning *et al.*, 2011), the results on feedlot performance remain equivocal. Neither commercial (Meissner *et al.*, 2010) nor controlled

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trials (Leeuw *et al.*, 2009) have shown consistent benefits to average daily gain (ADG) and feed conversion ratio (FCR), but probability tests suggest a 2.2% advantage in carcass yield (Meissner *et al.*, 2010). The objective of the present study was to investigate this further and, in addition, to establish whether the adaptation phase on typical US feedlot diets, as on typical South African diets (Henning *et al*., 2009), can be shortened if *M.e.* is administered, which, if successful, should be beneficial to the cost of production.

The experiment was conducted in a manner consistent with the applicable laws and regulations governing the humane care of animals, and consistent with the KSU Institutional Animal Care and Use (IACUC) protocol No. 1977, as well as the Centre for Veterinary Medicine under the Investigation Food Additive application No. 11-171. *Megasphaera elsdenii* NCIMB 41125 was cleared for experimental use in the USA by the USDA Animal-Plant Health Inspection Service (permit numbers SOU-855 and TRN-855).

Approximately 130 yearling crossbred steers of 390 – 450 kg body weight were obtained, weighed upon arrival, vaccinated against relevant viral and clostridial diseases, treated for internal and external parasites, and identified with individually numbered ear tags. They were then placed in pens accommodating 15 to 30 head each, and fed lucerne hay plus a vitamin-mineral-salt supplement for a number of weeks to acclimate and to limit variation in gastrointestinal fill. Ten days before commencement of the experiment, the steers were again weighed, stratified by weight and a subset of 80 was selected, which differed little in weight. The subset was then allocated individually to 6.5 m × 1.6 m pens, which were housed 20 each in four identical barns. The pens were equipped with fence-line feed bunks and a water fountain shared between adjacent pens. The 80 steers were fed chopped lucerne hay and the vitamin-mineral-salt supplement for another 10 days before being weighed, stratified by weight, and allotted randomly within strata to the four barns and the 20 individual pens per barn. The pens within the barns were assigned randomly to one of two drench treatments, consisting of an oral dose of 200 mL of liquid culture media containing $10^{11}$ viable *Megasphaera elsdenii* NCIMB 41125 cells (*M.e.* treatment) or a placebo consisting of an equal volume of the culture media containing no organism (placebo treatment). Care was taken in the assignment that *M.e.* and placebo steers did not share a common water fountain to limit the opportunity of cross-inoculation.

Within each barn, steers were again stratified by weight and assigned randomly to each of four groups consisting of two adaptation periods (17 or 8 days) with and without the organism (*M.e.* or placebo). In the 17-day adaptation regimen, five diets (5–transition) were used: 45% roughage/55% concentrate fed on days 1 – 4; 35% roughage/65% concentrate fed on days 5 – 8; 25% roughage/75% concentrate fed on days 9 – 12; 15% roughage/85% concentrate fed on days 13 – 16, and 6% roughage/94% concentrate (final diet) fed on days 17 – 95. In the 8-day adaptation regimen (3–transition) only three of the five diets were used: 45% roughage/55% concentrate fed on days 1 – 3; 25% roughage/75% concentrate fed on days 4 – 7, and 6% roughage/94% concentrate (final diet) fed on days 8 – 95. The dietary compositions are shown in Table 1.

Steers were fed individually for 63 days. The amount of feed offered to each steer was determined at about 12:00 and the entire daily amount was delivered into the feed bunk by 14:00. Residual feed was removed daily, dried and weighed in order to calculate daily feed dry matter (DM) intake per animal. At the end of the 63-day period, the five steers representing each treatment in a particular barn were combined with the five steers of the same treatment in a second barn and placed in a group pen. Between days 64 and 95, the trial steers were therefore fed in pens of 10 head each, and intake was not monitored.

Steers were weighed individually on days 1, 28, 63 and 95, prior to feeding. During the trial they were observed continuously for clinical signs of digestive and/or metabolic disorders and other diseases. These were minimal and did not affect trial integrity. On day 95 the 80 steers were transported to a commercial abattoir for slaughter. Measurements include daily DM intake until day 63, steer weights and ADG for days 1 – 28, 1 – 63 and 1 – 95, feed efficiency (FCR) for days 1 – 28 and 1 – 63, liver abscesses, hot carcass weights, fat thickness over the $12^{th}$ rib, percentage kidney, pelvic and heart fat, and intramuscular fat deposition as a measure of marbling.

The study was designed as a randomized complete block of a 2 × 2 factorial arrangement with 20 observations per treatment. Individual animal constituted the experimental unit and factors consisted of transition regimen (5–transition vs. 3–transition) and dose treatment (*M.e.* vs. placebo). The data were analysed using the generalized linear models procedure of the Statistical Analysis System. The statistical model included fixed effects of barn (four barns were used), transition regimen, dose treatment and the two-way interaction between transition regimen and dose treatment. Initial weight and pre-trial rate of gain were included as covariates. Since degrees of freedom were limited and between-animal variation large, even after careful blocking for weight and other measures, statistical significance was accepted at the 10% level of probability and trends at the 20% level of probability.

**Table 1** Composition of the transition diets on a dry matter (DM) basis (kg/ton)

| | Transition diets | | | | Final diet |
|---|---|---|---|---|---|
| Ingredients | 1 | 2 | 3 | 4 | 5 |
| Lucerne hay | 450 | 350 | 250 | 150 | 60 |
| Steam flaked maize | 415 | 545 | 635 | 724 | 800 |
| Corn steep liquor | 50 | 50 | 50 | 50 | 50 |
| Tallow | 40 | - | - | - | - |
| Soybean meal | 3.3 | 8.6 | 14 | 19.3 | 26.4 |
| Urea | 5.2 | 6.4 | 7.6 | 8.8 | 10.4 |
| Ground limestone | 2.8 | 6.0 | 9.1 | 12.3 | 16.5 |
| Potassium chloride | - | 0.8 | 1.5 | 2.3 | 3.3 |
| Vitamin & mineral premix[a] | 4.0 | 4.0 | 4.0 | 3.9 | 3.8 |
| Rumensin premix[b] | 29.4 | 29.4 | 29.4 | 29.4 | 29.4 |

[a] Formulated to provide 3 kg/ton salt; 2200 IU/kg vitamin A; 11 IU/kg vitamin E; 0.1 mg/kg cobalt; 10 mg/kg copper; 0.6 mg/kg iodine; 60 mg/kg manganese; 0.3 mg/kg selenium and 60 mg/kg zinc in the feed DM.
[b] Formulated to provide 36 mg monensin/kg feed dry matter in a ground maize carrier.

**Table 2** Body weight, dry matter intake (DMI), average daily gain (ADG) and feed conversion of steers adapted from an all-roughage to a high-concentrate diet, using a series of five or three transition diets and dosed with a placebo or with *Megasphaera elsdenii* NCIMB 41125 (*M.e.)*

| | 5–transition | | 3–transition | | | $P^2$ values | | |
|---|---|---|---|---|---|---|---|---|
| Parameter | Placebo | *M.e.* | Placebo | *M.e.* | SEM[1] | Dose | Trans. | D x T |
| n | 20 | 20 | 20 | 20 | - | - | - | - |
| Initial weight (kg) | 408 | 408 | 408 | 408 | 4.1 | - | - | - |
| Weight day 28 (kg) | 462 | 468 | 463 | 463 | 4.1 | 0.55 | 0.63 | 0.52 |
| Weight day 63 (kg) | 513 | 531 | 521 | 521 | 5.4 | 0.11 | 0.83 | 0.11 |
| DMI, d 1 – 28 (kg) | 7.87 | 8.19 | 7.66 | 7.64 | 0.32 | 0.64 | 0.24 | 0.58 |
| DMI, d 1 – 63 (kg) | 8.23 | 8.74 | 8.40 | 8.41 | 0.22 | 0.25 | 0.71 | 0.27 |
| ADG, d 1 – 28 (kg/d) | 1.96 | 2.14 | 1.98 | 1.97 | 0.15 | 0.55 | 0.63 | 0.52 |
| ADG, d 1 – 63 (kg/d) | 1.68 | 1.96 | 1.80 | 1.80 | 0.09 | 0.11 | 0.82 | 0.11 |
| FCR, d 1 – 28 (kg/kg) | 3.85 | 3.90 | 3.97 | 4.07 | 0.24 | 0.76 | 0.56 | 0.92 |
| FCR, d 1 – 63 (kg/kg) | 4.82 | 4.53 | 4.75 | 4.74 | 0.16 | 0.33 | 0.66 | 0.37 |

[1] Standard error of the mean; [2] Probability.
FCR - feed conversion ratio.

Dry matter intake (DMI) did not differ significantly, for either the transition regimen (Trans.) or the dose treatment (Dose), whether during days 1 – 28 (steers in adaptation) or during days 1 – 63; neither was the interaction (D × T) significant (Table 2). Higher intakes with less animal variation and day-to-day variation during the initial adaptation phases when *M.e.* was administered have been reported in most experimental station trials (Henning *et al.*, 2010a; b; Meissner *et al.*, 2010), although there are exceptions

(Leeuw *et al.*, 2009), especially in commercial trials (Meissner *et al.*, 2010). The reasons could be associated with rate of adaptation, dietary energy level and grain processing. Similar to the result of 5–transition vs. 3–transition treatments here, Henning *et al.* (2009) found no significant difference in DMI between steers adapted for 1, 5, 9, 13, 17 or 21 days when dosed with *M.e.*

Together with DMI, steer weights, ADGs and FCRs for the periods 1 – 28 days and 1 – 63 days are reported in Table 2. Transition period did not have an effect on body weight, ADG and FCR, supporting the results of Henning *et al*. (2009). Steers on *M.e.* treatments had higher body weights and ADGs than those on placebo, the results at 63 days approaching significance ($P = 0.11$). As the probability value of D × T also approached significance ($P = 0.11$), the results suggest that the effect of *M.e.* inoculation was more pronounced in the 5–transition treatments than the 3–transition.

When the ADG results of 1 – 95 day period weight gains were adjusted to account for variation in gastrointestinal fill (Table 3), ADG in *M.e.* compared with the placebo was higher ($P = 0.09$), and so was hot carcass weight ($P = 0.10$) with on average a 9.4% and a 2.3% advantage respectively in favour of the *M.e.* treatments. The 5–transition treatments tended to have higher carcass adjusted ADGs ($P = 0.12$) and hot carcass weights ($P = 0.13$) than the 3–transition treatments, whereas the 3–transition treatments tended to have more liver abscesses ($P = 0.14$) than the 5–transition treatments. Carcass characteristics were not affected by dose or transition treatments.

**Table 3** Day 95 (final) body weight, average daily gain (ADG), liver abscesses, carcass weight, dressing percentage and carcass characteristics of steers adapted from an all-roughage to a high-concentrate diet, using a series of five or three transition diets and dosed with a placebo or *Megasphaera elsdenii* NCIMB 41125 (*M.e.*)

| | 5–transition | | 3–transition | | | $P^2$ values | | |
|---|---|---|---|---|---|---|---|---|
| Parameter | Placebo | *M.e.* | Placebo | *M.e.* | SEM[1] | Dose | Trans. | D x T |
| n | 20 | 20 | 20 | 20 | - | - | - | - |
| Weight day 95, kg | 549 | 552 | 535 | 548 | 6.6 | 0.20 | 0.18 | 0.46 |
| ADG day 1 - 95, kg | 1.49 | 1.52 | 1.34 | 1.48 | 0.07 | 0.20 | 0.18 | 0.46 |
| Carcass adjusted ADG, kg[3] | 1.25 | 1.31 | 1.08 | 1.25 | 0.07 | 0.09 | 0.12 | 0.47 |
| Liver abscesses, % | 4.7 | 5.5 | 20.1 | 9.7 | 6.6 | 0.47 | 0.14 | 0.40 |
| Hot carcass weight, kg | 334 | 338 | 324 | 335 | 4.4 | 0.10 | 0.13 | 0.48 |
| Dressing percentage | 63.4 | 63.8 | 63.1 | 63.6 | 0.44 | 0.35 | 0.56 | 0.88 |
| Subcutaneous fat 12$^{th}$ rib, cm | 0.63 | 0.74 | 0.64 | 0.57 | 0.06 | 0.75 | 0.23 | 0.16 |
| Internal fat, %[4] | 1.73 | 1.82 | 1.84 | 1.90 | 0.09 | 0.41 | 0.30 | 0.84 |
| Marbling score[5] | 440 | 467 | 453 | 446 | 10.3 | 0.37 | 0.70 | 0.11 |

[1] Standard error of the mean; [2] Probability.
[3] Final weight was computed as carcass weight divided by a standardized dressing percentage of 63.5% to account for differences in gastrointestinal fill. ADG was then computed as (adjusted final weight – initial live weight)/days on feed.
[4] Kidney, pelvic and heart fat.
[5] Subjective determination of intramuscular fat deposited within the longissimus muscle between rib 12 and 13 This is based on the USDA scoring system where 100 - 199 = practically devoid; 200 - 299 = traces; 300 - 399 = slight; 400 - 499 = a small amount of intramuscular fat.

Leeuw *et al.*'s (2009) results did not show an advantage to ADG and FCR with *M.e.* administration, measured on a live weight or on a carcass basis. In the review by Meissner *et al*. (2010), no benefit was reported of *M.e.* inoculation to live weight ADG and FCR, which could be explained partly by variation in gastrointestinal fill, as shown here. The benefit to carcass gain reported in this review (Meissner *et al.*, 2010) is supported by this study. Thus, the results suggest that a single dose of *Megasphaera elsdenii* strain

NCIMB 41125 at the initiation of the adaptation phase should provide a small benefit in carcass gain. Although there were no major differences in transition treatments, trends imply that, compared with steers on the 5–transition treatments, steers on the 3–transition treatments might have been health compromised, suggesting that feedlot operators in the US on similar diets to the diet in the present study should be cautious in shortening the transition phase, even when steers are inoculated with strain *M.e.* NCIMB 41125. This is in contrast with the results of Henning *et al.* (2009) on typical ground maize and hominy chop-based South African feedlot diets.

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