Evaluation of essential oil and injectable trace mineral on bull growth performance and fertility

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INTRODUCTION

Essential oils are naturally occurring secondary plant metabolites that can be steam volatilized or extracted using organic solvents (Calsamiglia et al., 2007). Essential oils (EO) can improve feed efficiency in livestock (Bampidis et al., 2005). Wallace (2004) explains specific properties that inhibit degradation of protein in the rumen which increases the amino acid availability for intestinal uptake. Khiaosa-ard and Zebeli (2014) summarized the effects of EO and their bioactive compounds on rumen fermentation in vivo and investigated animal performance and feed efficiency in multiple ruminant species using a meta-analysis approach. This analysis concluded that supplementation of EO can enhance rumen fermentation by decreasing the acetate to propionate ratio which favors growth performance outcomes in beef cattle.

Feed cost is the single largest variable expense associated with the production of beef, and it accounts for approximately 65% of the expense required to maintain a breeding herd (Arthur et al., 2004; Van der Westhuizen et al., 2004). Developing bull programs which are designed to express the genetic potential for growth relies heavily on constant nutrient availability. Research that combines multiple technologies to improve proficiency for growth and development is warranted. Therefore, the objective of this study is to evaluate the effects of essential oil mixtures (EOM) in conjunction with injectable trace mineral (ITM) on growth performance and fertility of growing, yearling bulls.

MATERIALS AND METHODS

All animal handling procedures were approved in accordance with the Angelo State University’s Institutional Animal Care and Use Committee Protocol no. 18-201. This study was conducted at the Angelo State University Management, Instruction, and Research station (MIR). Data were collected from 2016 to 2017 spring born Angus bulls. All bulls originate from the Angelo State University Angus herd. Bulls \( n = 37 \) (2016; \( n = 29 \), 2017) managed at the MIR, were weaned and confined to dry lots, fed a total mix ration (TMR), and ration percentages as well as nutrient composition is presented in Table 1. All bulls also had access to fresh water and hay grazer hybrid (sorghum almund) ab libitum from weaning through study conclusion.

In each year, days 35 and 32 with respect to year, bulls were weaned and exposed to CONTROL diet for TMR adaptation. Weaned bulls were initially stratified by body weight (BW) at weaning and sire across two diet groups (two separate, but similar pens with similar bunk

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space and area). Group 1 consisted of the EOM-consuming group (EOM), and group 2 consisted of the EOM naïve control group (CONTROL). Bulls were then stratified by BW and sire within each diet group across two ITM subsets. The bulls receiving the ITM were assigned (ITM–Yes) designation and the bulls receiving no ITM injections were assigned (ITM–No) designation. All trial procedures and trial days with corresponding dates are illustrated in Table 2.

At day 0 in both years, bulls in the EOM groups were transitioned to the dietary EOM at a diet inclusion rate of 0.004 kg per head daily as per product label instruction. Bulls in the ITM–Yes subset were administered ITM at a dosage rate of 1 mL per 45.35 kg of BW, as per product label instruction, immediately following bull BW collection on days 42 and 70 in year 1 and days 47 and 75 in year 2. On day 91 in year 1 and day 97 in year 2, an initial semen sample was collected via electro-ejaculator and discarded to verify a common reproduction tract dispel of all bulls. At day 98 in year 1 and day 103 in year 2, final semen samples were collected and semen motility scores were assessed using the same trained personnel in both years using a 5-point scale as described in Table 3.

### Table 1. Ingredient and nutritional composition (DM)

| Ingredient       | EOM diet % | CONTROL diet % |
|------------------|------------|----------------|
| Cracked corn     | 30.00      | 30.00          |
| DDG + solubles   | 20.00      | 20.00          |
| Cottonseed hulls | 30.00      | 30.00          |
| Alfalfa pellets  | 14.50      | 14.50          |
| Molasses         | 4.00       | 4.00           |
| Mineral premix\(^1\) | 2.5   | 2.5            |
| Essential oil mixture | 0.06 | 0.00         |
| Nutrient, DM     |            |                |
| DM %             | 89.35      | 89.35          |
| Crude protein %  | 15.55      | 15.55          |
| NE\(\text{M} \times \text{kg} \) | 0.30 | 0.30          |
| NE\(\text{g} \times \text{kg} \) | 0.19 | 0.19          |
| Crude fat %      | 5.44       | 5.44           |
| ADF              | 29.19      | 29.19          |
| NDF              | 40.30      | 40.30          |
| Calcium          | 0.88       | 0.88           |
| Phosphorus       | 0.38       | 0.38           |

\(^1\)Premix: 17.5–19%Ca, 18.1–20.6%NaCl, 1,075 ppm Mn, 1,780 ppm Zn, 3.95 ppm Se, 89,184 IU/kg Vitamin A, 29,728.03 ppm Vitamin D, 493.83 ppm Vitamin E.

### Table 2. Procedure days and associated dates across years

| Procedure                                              | 2016–2017       | 2017–2018       |
|--------------------------------------------------------|-----------------|-----------------|
| Wean, sort, collect weights, scrotal measurements       | −35             | −32             |
| treatments begin (ITM and EOM)                         | 09/28/2016      | 09/26/2017      |
| Collect weights, Scrotal Measurements                   | 0              | 0               |
| Collect weights, Scrotal Measurements                   | 11/02/2016      | 10/27/2017      |
| Collect weights, Scrotal Measurements                   | 12/14/2016      | 12/14/2017      |
| Collect weights, Scrotal Measurements                   | 01/11/2017      | 01/11/2018      |
| Collect weights, Scrotal Measurements Semen evaluation | 02/08/2017      | 02/08/2018      |

### Table 3. Semen grading scores for semen motility parameters

| Scale | Grade   | Characteristics                                                                 |
|-------|---------|---------------------------------------------------------------------------------|
| 5     | (+++++) | More than 80% of the sperm show vigorous motion. Swirls are formed due to the movements of the sperm. The movements are rapid and changing and hard to observe individual sperm samples in undiluted semen |
| 4     | (++++)  | About 70% to 80% of the sperm show vigorous motion which causes waves and eddies but not as vigorous as the excellent grade |
| 3     | (+++)   | Very good About 45% to 70% of the sperm are in motion. Motion is vigorous. Waves and eddies are formed slow across the sample |
| 2     | (++     | 30% to 40% of the spermatozoa are in motion. Movements are vigorous. No waves or eddies present |
| 1     | (+)     | Fair Little to no motility found. Less than 20% of the spermatozoa are in motion. Not progressive and little oscillation |

Adapted from Hossain et al. (2012). This table illustrates the measure of motility of semen samples presented in this report.
**RESULTS AND DISCUSSION**

**Weight Measures**

Due to the stratification procedures, no weight differences were observed for any treatment or treatment interactions at day 0 within or between any diet group or ITM subset. However, differences in overall weight measures were observed due to the main effect of ITM. Bulls in the ITM-Y subset exhibited greater overall weight measures ($P = 0.05$), and these observations are illustrated in Figure 1.

This difference in the overall weight measure can be better explained by examining the differences in post-weaning ADG.

**Post-wean ADG**

Significant sources of variation were observed in these data for post-weaning ADG due to the diet × ITM (year) term only and these data are presented in Table 4. In the 2017–2018 yr, the ITM-Y subset bulls achieved a greater post-weaning ADG when compared with the ITM-No subset within the EOM diet consuming group (2.53 and 1.02, respectively; $P < 0.01$).

**Semen Motility**

Differences in semen motility scores were also observed due to the diet × ITM (year) term only and these data are presented in Table 5. Significant differences were observed within the CONTROL diet bulls only in both years as the ITM-Y subset in

| Table 4. Post weaning ADG of Diet × ITM nested within year |
|-----------------------------------------------------------|
| **Diet** | **ITM-Yes** | **ITM-No** | **SEM** | **P** | **ITM-Yes** | **ITM-No** | **SEM** | **P** |
| EOM      | 2.17        | 2.02       | 0.15    | 0.32  | 2.53        | 1.02       | 0.16    | <0.01 |
| Control  | 2.09        | 1.96       | 0.13    | 0.33  | 1.67        | 1.78       | 0.12    | 0.48  |

Least squares means of semen motility scores for Diet × ITM (Year).

| Table 5. Semen motility scores of Diet × ITM nested within year |
|---------------------------------------------------------------|
| **Diet** | **ITM-Yes** | **ITM-No** | **SEM** | **P** | **ITM-Yes** | **ITM-No** | **SEM** | **P** |
| EOM      | 3.18        | 2.79       | 0.68    | 0.77  | 3.73        | 3.38       | 0.73    | 0.64  |
| Control  | 3.70        | 2.33       | 0.61    | <0.01 | 4.33        | 2.03       | 0.69    | <0.01 |

Least squares means of semen motility scores for Diet × ITM (Year).

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diet × ITM (year), diet × ITM × day. These measures were analyzed as repeated measures with the first-order autoregressive covariance structure being used. Post-weaning ADG and semen motility observations were analyzed with a model using similar fixed effects and only the diet × ITM (year) interaction. These models did not include the repeated measures statements. Differences in the least squares means using the PDIFF option were observed with fixed effects resulting in $P \geq 0.15$ and interactions resulting $P \geq 0.25$ were removed prior to final analysis.

**Figure 1.** Weight measures, main effect of injectable trace mineral. Least squares means of weight measures for the main effect of injectable trace mineral. a,b Superscripts designate differences ($P \leq 0.05$).
both studies had greater least squares’ means estimates than the ITM-No bulls ($P < 0.01$). Although these differences were observed at the time of analysis, caution is warranted as to the interpretation of the biological differences these data imply. Alexander (2008) explains that semen samples that have a 30% or greater progressive motility score are declared as acceptable breeders in most breeding soundness exam (BSE) criteria. Therefore, all bulls in these data with motility scores of “2” or greater would, likely, pass a standard BSE for motility.

**Implications**

These data suggest that dietary EOM alone has limited impact on growth measures and semen motility observations. But when applied in conjunction with ITM, it can improve post-weaning ADG. Furthermore, implementing trace mineral homeostasis via ITM can improve weight gain and augmented semen motility scores.

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