

Route of Administration Determines Effectiveness of Single-Use Trace Mineral Products in Beef Cattle

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Summary and Implications

An injectable trace mineral product increased plasma Mn, Se, and Zn concentrations within 8 h and liver Se concentrations through d 29. These products are an effective way to rapidly increase trace mineral status as they are delivered directly into the blood stream. Boluses did not increase liver mineral (Se) concentrations until 120 days after administration, suggesting these products may be an effective strategy to improve trace mineral status in the long-term. Products that were administered orally (drenches and pastes) had minimal effects on plasma and liver mineral concentrations, likely because interaction with dietary antagonists hindered trace mineral absorption. Beef cattle producers should select single-use trace mineral products based on how quickly a status change is needed.

Introduction

Trace minerals (TM) including copper (Cu), manganese (Mn), selenium (Se), and zinc (Zn) are essential to support optimum immune function and growth of beef cattle. Producers commonly supplement TM in the diet to prevent mineral deficiencies which can result from low TM content of feedstuffs and/or low availability of TM in feedstuffs due to the presence of dietary antagonists. Single-use TM supplements such as injectables, drenches, pastes, and boluses are also available to producers. These products may be beneficial for ensuring adequate TM status when prior status is unknown (e.g. feedlot arrival) or when consistent dietary supplementation is not feasible (e.g. grazing cows or stocker cattle). The objective of the current study was to compare the short-term and long-term effects of several commercially available single-use TM products on plasma and liver TM concentrations of beef steers.

Materials and Methods

This study utilized 56 newly weaned, Angus crossbred steers from a single source. On d -21, steers were weighed (545 ± 30 lb), vaccinated, and treated for parasites. Steers were blocked by BW and randomly

assigned to receive 1 of 7 trace mineral products on d 0 (n = 8 steers/treatment): none (CON); injectable Multimin@90 (ITM; Multimin USA, Fort Collins, CO; 1 mL per 100 lb BW); MineralMax® Drench (MMD; Aspen Veterinary Resources Ltd., Liberty, MO; 6 mL per 100 lb BW); MineralMax® Paste (MMP; Aspen Veterinary Resources Ltd., Liberty, MO; 30 mL per steer); Starting Fluid Drench (SFD; Kentucky Nutrition Service, Lawrenceburg, KY; 11 mL per steer); Se365 bolus (Se365; Pacific Trace Minerals Inc., Ashland, OR; 1 bolus per steer); or Reloader250 bolus (Rel250; Provimi North America Inc., Brookville, OH; 1 bolus per steer). Control steers received an injection of sterilized saline (1 mL/100 lb BW) and a sham bolus. Steers who received an oral treatment (paste, drench, or bolus) also received an injection of sterilized saline and steers receiving injectable treatments (ITM) received a sham bolus.

To avoid pen effects, treatments were stratified across pens such that at least one steer per treatment was housed in each pen (8 steers/pen). Pens were equipped with a bunk that measures individual feed disappearance. Steers were divided into two groups (A and B) and stagger started by 5 days to accommodate sampling timepoints; both groups contained all treatments. Steers were fed a common corn silage based growing diet and a cracked corn-based finishing diet formulated to meet or slightly exceed nutrient requirements (Table 1). Consecutive day body weights were obtained prior to treatment administration (d -1 and 0) and at the end of the trial (d 122 and 123); ADG was calculated from the average of these weights. Blood was collected from all steers immediately prior to treatment administration as well as 8, 24, and 48 h post-treatment. Liver was collected from all steers prior to treatment administration (d -7) as well as 2, 15, 29, 49, 65, 91, and 120 d post-treatment. Plasma and liver samples were analyzed for Cu, Mn, Se, and Zn concentrations utilizing inductively coupled plasma mass spectroscopy.

Steer BW and ADG were analyzed using the Mixed Procedure of SAS 9.4 with the fixed effect of treatment. Steer DMI as well as plasma and liver TM concentrations were analyzed as repeated measures with the fixed effects of treatment, time (week for DMI; hour for plasma; day for liver), and treatment \times time. Initial (pre-treatment) plasma and liver TM concentrations were used as covariates. Steer was the experimental unit (n = 8 steers/treatment) for all variables. Group (A or B) was tested initially in all models, found to be non-significant and subsequently removed from the final model. Liver Se

and Zn and plasma Cu, Mn, Se, and Zn were log transformed and the back transformed means and SEM are presented. Significance was declared at $P \leq 0.05$ and tendencies at $0.05 < P \leq 0.10$.

Results and Discussion

Trace mineral products did not affect initial BW (667 ± 34 lb), final BW (1068 ± 68 lb), ADG or DMI ($P \geq 0.75$; data not shown).

Based on plasma and/or liver reference ranges, steers had adequate TM status throughout the study. However, it is important to note that plasma and liver TM concentrations are not always sensitive or reliable indicators of TM status. For example, plasma Cu concentrations will remain adequate until liver Cu concentrations fall below a certain threshold while liver Cu concentrations will more readily reflect changes in dietary Cu intake. Plasma Cu concentrations were unaffected by treatment, time, or treatment \times time (data not shown). Alternatively, plasma Mn (**Figure 1**), Se (**Figure 2**), and Zn (**Figure 3**) concentrations were greatest for ITM compared to all other treatments 8 h post-administration (treatment \times time $P < 0.01$). Since ITM is administered subcutaneously, there is almost an immediate response in plasma TM concentrations. After 24 h, plasma Mn and Se concentrations remained elevated for ITM while plasma Zn concentrations were similar among treatments. After 48 h, plasma Se concentrations for ITM were greater than MMD, with all other treatments being intermediate. The effects of ITM on plasma TM concentrations observed in the current study are consistent with previous research.

No effects of treatment or treatment \times time were observed for liver Cu, Mn, or Zn concentrations (data not

shown). However, liver Se concentrations were greater for ITM compared to all other treatments on d 2 and 15 post-administration (treatment \times time $P < 0.01$; **Figure 4**). This increase is likely due to uptake of Se from the plasma (**Figure 2**). On d 29, liver Se concentrations for ITM were greater than CON and oral (MMD, MMP, SFD) treatments. Low absorption rates of TM in the intestine (5-40%) due to interaction with dietary antagonists could explain why the oral drenches and pastes had little effect on plasma or liver TM concentrations.

Although the Se365 bolus was not different from CON throughout the trial, effects of the Rel250 bolus became apparent later in the trial. On d 91, liver Se concentrations were greater for Rel250 compared to ITM and MMP. This trend was magnified on d 120 where liver Se concentrations were greater for Rel250 compared to all treatments except ITM and Se365. Ruminant pH may affect rate of bolus degradation which could explain why no bolus effects were observed until the second half of the study when steers were being fed a higher concentrate finishing diet. Had the study continued, it is predicted there would be greater separation between the bolus treatments and CON.

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Table 1. Ingredient and nutrient composition of common diets fed to steers throughout the trial

	Growing Diet ¹	Transition Diet ²	Finishing Diet ³
Ingredient (%DM)			
Corn silage	40	24	16
Cracked corn	30	44	53
Corn dried distillers grains with solubles	25	27	26
Micronutrients and carrier ⁴	5	5	5
Analyzed composition			
Crude protein ⁵ , %	15.4	-	15.9
NDF ⁵ , %	28.4	-	21.6
Ether extract ⁵ , %	4.0	-	4.6
Cu, mg/kg DM	10.4	-	10.4
Se mg/kg DM	0.36	-	0.34
Mn, mg/kg DM	19.0	-	18.8
Zn, mg/kg DM	30.5	-	26.7

¹Diet fed from Days -21 to 36 for group A and Days -25 to 41 for group B

²Diet fed from Days 37 to 43 for group A and Days 42 to 48 for group B

³Diet fed from Days 44 to 120 for group A and Days 49 to 120 for group B

⁴Provided Rumensin (Elanco Animal Health, Greenfield, IN) at 0.015% and trace minerals from all inorganic sources

⁵Chemical analysis completed by Dairyland Laboratories (Arcadia, WI)

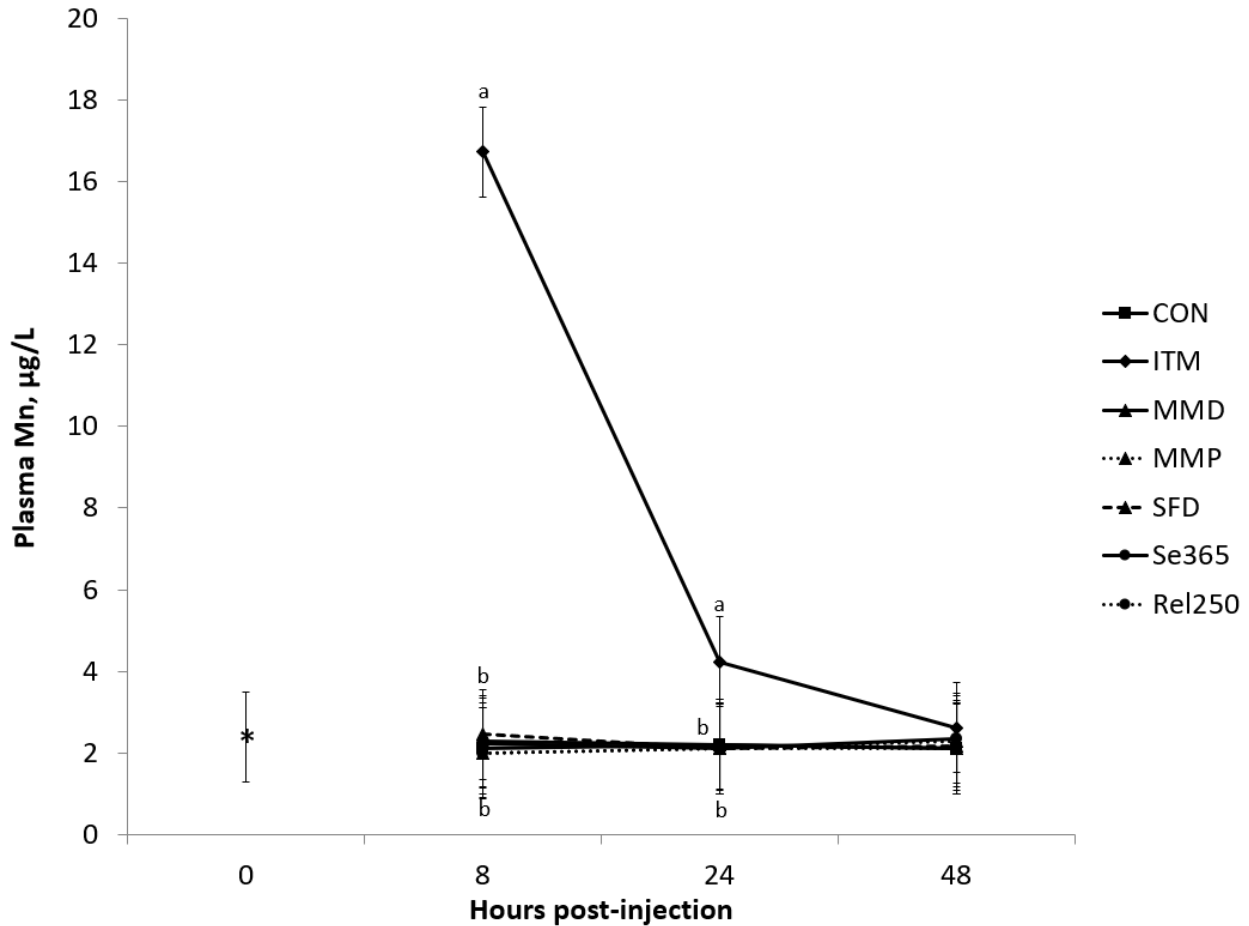


Figure 1. Effect of trace mineral product and time on plasma Mn concentrations over a 48-h period after product administration (treatment \times hour $P < 0.01$). CON = saline; ITM = Multimin90 (Multimin USA, Fort Collins, CO); MMD = Mineral Max Drench (Aspen Veterinary Resources Ltd., Liberty, MO); MMP = Mineral Max Paste (Aspen Veterinary Resources Ltd.); SFD = Starting Fluid Drench (Kentucky Nutrition Service, Lawrenceburg, KY); Se365 = Se365 bolus (Pacific Trace Minerals Inc., Ashland, OR); and REL250 = Reloader250 bolus (Provimi North America Inc., Brookville, OH). Differing letters (a-c) within an hour indicate a difference ($P \leq 0.05$). Initial (pre-treatment) plasma mineral concentrations (denoted by an asterisk) served as covariates in analyses.

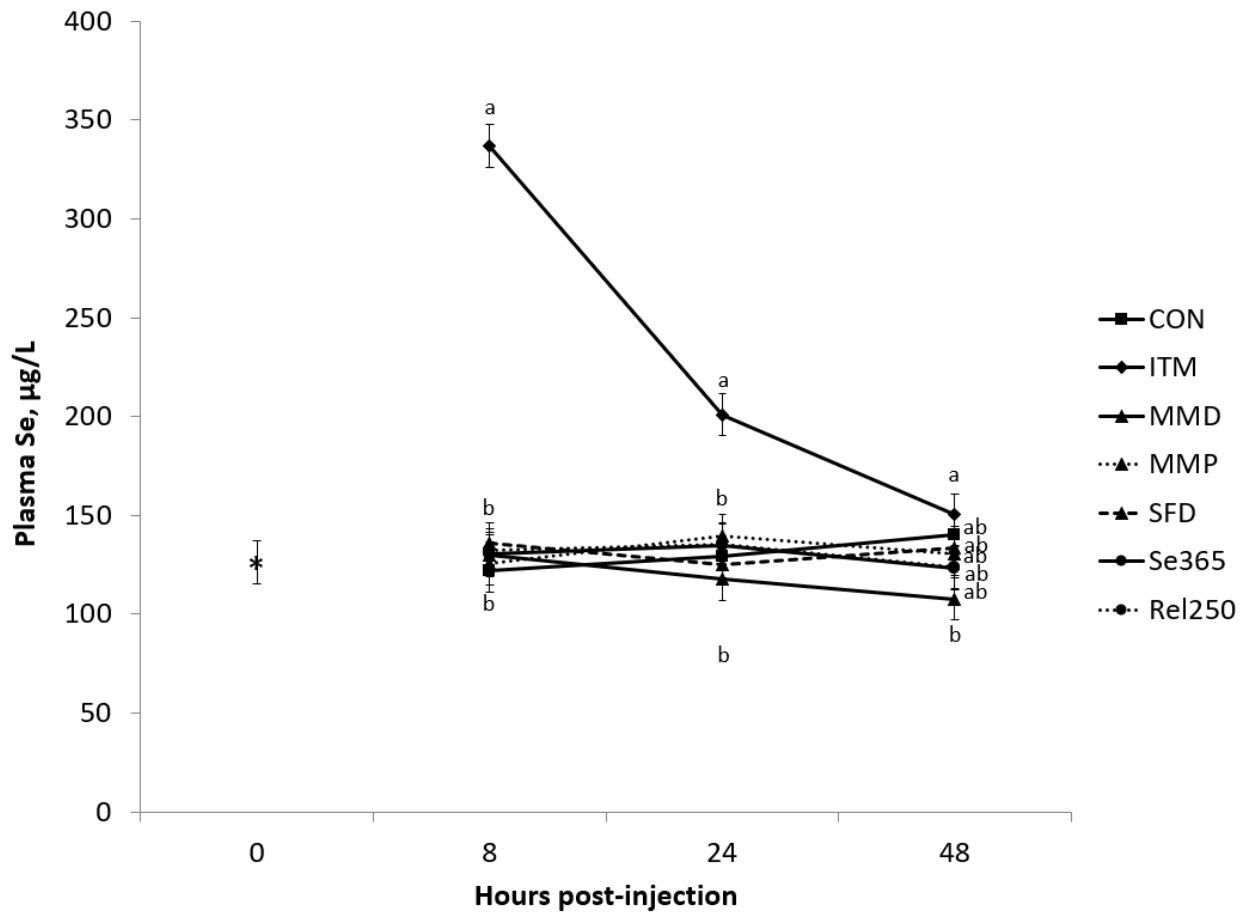


Figure 2. Effect of trace mineral product and time on plasma Se concentrations over a 48-h period after product administration (treatment \times hour $P < 0.01$). CON = saline; ITM = Multimin90 (Multimin USA, Fort Collins, CO); MMD = Mineral Max Drench (Aspen Veterinary Resources Ltd., Liberty, MO); MMP = Mineral Max Paste (Aspen Veterinary Resources Ltd.); SFD = Starting Fluid Drench (Kentucky Nutrition Service, Lawrenceburg, KY); Se365 = Se365 bolus (Pacific Trace Minerals Inc., Ashland, OR); and REL250 = Reloader250 bolus (Provimi North America Inc., Brookville, OH). Differing letters (a-c) within an hour indicate a difference ($P \leq 0.05$). Initial (pre-treatment) plasma mineral concentrations (denoted by an asterisk) served as covariates in analyses.

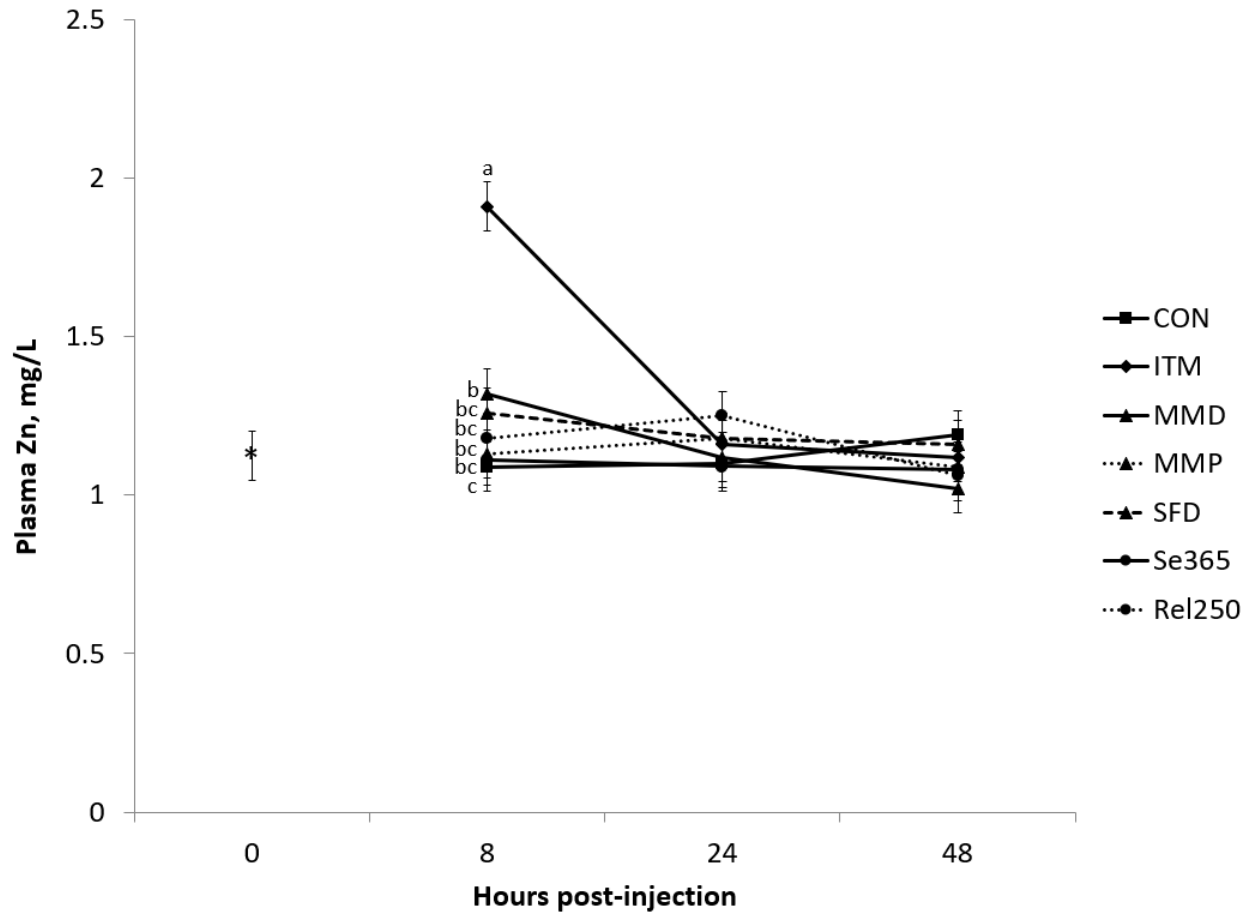


Figure 3. Effect of trace mineral product and time on plasma Zn concentrations over a 48-h period after product administration (treatment \times hour $P < 0.01$). CON = saline; ITM = Multimin90 (Multimin USA, Fort Collins, CO); MMD = Mineral Max Drench (Aspen Veterinary Resources Ltd., Liberty, MO); MMP = Mineral Max Paste (Aspen Veterinary Resources Ltd.); SFD = Starting Fluid Drench (Kentucky Nutrition Service, Lawrenceburg, KY); Se365 = Se365 bolus (Pacific Trace Minerals Inc., Ashland, OR); and REL250 = Reloader250 bolus (Provimi North America Inc., Brookville, OH). Differing letters (a-c) within an hour indicate a difference ($P \leq 0.05$). Initial (pre-treatment) plasma mineral concentrations (denoted by an asterisk) served as covariates in analyses.

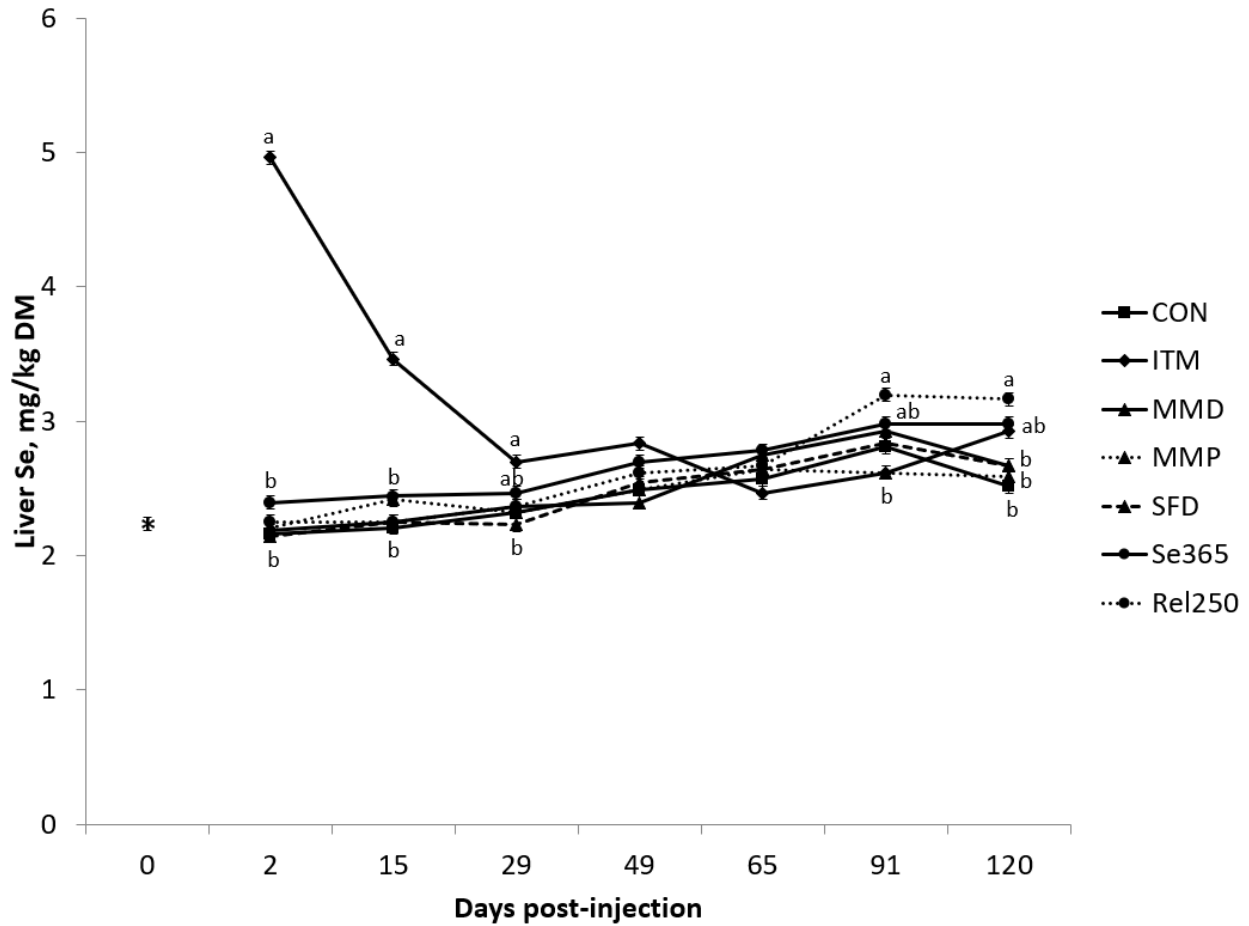


Figure 4. Effect of trace mineral product and time on liver Se concentrations over a 120-d period after product administration on d 0 (treatment \times day $P < 0.01$). CON = saline; ITM = Multimin90 (Multimin USA, Fort Collins, CO); MMD = Mineral Max Drench (Aspen Veterinary Resources Ltd., Liberty, MO); MMP = Mineral Max Paste (Aspen Veterinary Resources Ltd.); SFD = Starting Fluid Drench (Kentucky Nutrition Service, Lawrenceburg, KY); Se365 = Se365 bolus (Pacific Trace Minerals Inc., Ashland, OR); and REL250 = Reloader250 bolus (Provimi North America Inc., Brookville, OH). Differing letters (a, b) within a day indicate a difference ($P \leq 0.05$). Initial (pre-treatment) liver Se concentrations (denoted by an asterisk) served as covariates in analysis.