

Table of Contents

ABSTRACT	ii
ACKNOWLEDGEMENTS	iv
LIST OF TABLES	viii
LIST OF FIGURES	xii
LIST OF APPENDIX TABLES	xvii
INTRODUCTION	1
REVIEW OF LITERATURE	3
Markers in Ruminant and Equine Nutrition	5
Marker Dosing Methods	5
Verification of Marker Results	6
Internal Markers	6
Rare-Earth Markers	8
⁸⁹ Yttrium	9
⁹¹ Yttrium	9
External Markers	10
Chromium	11
Diurnal Variation	12
Ytterbium	13
Fecal Kinetics	16
OBJECTIVES	20

MATERIALS AND METHODS	21
RESULTS	31
Experiment 1	31
Experiment 2	34
DISCUSSION	43
Experiment 1	43
Experiment 2	46
IMPLICATIONS	50
LITERATURE CITED	51
TABLES	59
FIGURES	90
APPENDIX	132
VITA	170

List of Tables

<u>Table</u>	<u>Page</u>
1. Fecal recovery of yttrium (R_Y , %) for horses offered orchardgrass/alfalfa hay (Diet 1), and tall fescue/alfalfa hay (Diet 2) in Experiment 1	59
2. Total collection DMD (D_{TC} , %) and estimated DMD (D_E , %) for yttrium, for horses offered orchardgrass/alfalfa hay (Diet 1), and tall fescue/alfalfa hay (Diet 2) in Experiment 1	60
3. Estimates of fit of pooled fecal chromium concentration data to a one-compartment model, model parameters, and calculated variables in horses offered orchardgrass/alfalfa hay using total collection data (Diet 1a), or fecal grab data (Diet 1b), and tall fescue/alfalfa hay using total collection data (Diet 2a), or fecal grab data (Diet 2b), in Experiment 1	61
4. Fits of data to a one-compartment model of fecal kinetics without a delay, the administration curve, the post-administration curve, and the total curve with a delay between administration of an oral dose of Cr and its entry into the compartment, in horses offered orchardgrass/alfalfa hay using total collection data (Diet 1a), or fecal grab data (Diet 1b), and tall fescue/alfalfa hay using total collection data (Diet 2a), or fecal grab data (Diet 2b), in Experiment 1	62
5. Fits of data to a one-compartment model of fecal kinetics without a delay, the administration curve, the post-administration curve, and the total curve with a delay between administration of an oral dose of Cr and its entry into the compartment, in horses offered orchardgrass/alfalfa hay using total collection data in Experiment 1	63
6. Estimates of fit of individual fecal chromium concentration data to a one-compartment model, model parameters, and calculated variables in horses offered orchardgrass/alfalfa hay using total collection data (Diet 1a) in Experiment 1	64
7. Total collection fecal output (FO_{TC} , kg/d DM), and estimates of fecal output (FO_{CA} , kg/d DM) from the one-compartment model using total collection Cr data for horses offered orchardgrass/alfalfa hay (OGTC, Diet 1a) and tall fescue/alfalfa hay (TFTC, Diet 2a), in Experiment 1	65
8. Total collection fecal output (FO_{TC} , kg/d DM), and estimates of fecal output (FO_{CA} , kg/d DM) from the one-compartment model using fecal grab Cr data for horses offered orchardgrass/alfalfa hay (OGGR, Diet 1b) and tall fescue/alfalfa hay (TFGR, Diet 2b), in Experiment 1	66

9. Turnover times (TT, h) from the chromium one-compartment model, using total collection data, for horses offered orchardgrass/alfalfa hay (OGTC, Diet 1a) and tall fescue/alfalfa hay (TFTC, Diet 2a), in Experiment 1	67
10. Turnover times (TT, h) from the chromium one-compartment model, using fecal grab data for horses offered orchardgrass/alfalfa hay (OGGR, Diet 1b) and tall fescue/alfalfa hay (TFGR, Diet 2b), in Experiment 1	67
11. Prefecal mass (PFM, kg DM) from the chromium one-compartment model, using total collection data, for horses offered orchardgrass/alfalfa hay (OGTC, Diet 1a) and tall fescue/alfalfa hay (TFTC, Diet 2a), in Experiment 1	68
12. Prefecal mass (PFM, kg DM) from the chromium one-compartment model, using fecal grab data for horses offered orchardgrass/alfalfa hay (OGGR, Diet 1b) and tall fescue/alfalfa hay (TFGR, Diet 2b), in Experiment 1	68
13. Fecal recovery of chromium (R_{CR} , %) for horses offered orchardgrass/alfalfa hay (Diet 1a) and tall fescue/alfalfa hay (Diet 2a), using total collection fecal samples, in Experiment 1	69
14. Fecal recovery of chromium (R_{CR} , %) for horses offered orchardgrass/alfalfa hay (Diet 1b) and tall fescue/alfalfa hay (Diet 2b), using fecal grab data, in Experiment 1	69
15. Diurnal variation in fecal concentrations (mg/kg, DM) of chromium for individual horse fecal grab samples collected on d 8 of dosing, for horses offered orchardgrass/alfalfa hay (Diet 1) in Experiment 1	70
16. Diurnal variation in fecal concentrations (mg/kg, DM) of chromium for individual horse fecal grab samples collected on d 8 of dosing, for horses offered tall fescue/alfalfa hay (Diet 2) in Experiment 1	71
17. Partial DMD (D_s , %) of fat-and-fiber, and sugar-and-starch supplements offered to horses in Experiment 2	72
18. Fecal recovery of yttrium (R_Y , %) for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3) and orchardgrass/alfalfa hay and sugar-and-starch supplement (Diet 4) in Experiment 2	73
19. Total collection DMD (D_{TC} , %) and estimated DMD (D_E , %) for yttrium, for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3) and orchardgrass/alfalfa hay and sugar-and-starch supplement (Diet 4) in Experiment 2	74

20. Fecal recovery of ytterbium (R_{YbI} , %) for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3Yb) and orchardgrass/alfalfa hay and sugar-and-starch supplement (Diet 4Yb) in Experiment 2	75
21. Total collection DMD (D_{TC} , %) and estimated DMD (D_E , %) for ytterbium, for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3) and orchardgrass/alfalfa hay and sugar-and-starch supplement (Diet 4) in Experiment 2	76
22. Estimates of fit of pooled fecal chromium or ytterbium concentration data to a one-compartment model, model parameters, and calculated variables in horses offered orchardgrass/alfalfa hay and fat-and-fiber (FF) supplement (Diet 3Cr and 3Yb), or sugar-and-starch (SS) supplement (Diet 4Cr and 4Yb), in Experiment 2	77
23. Fits of data to a one-compartment model of fecal kinetics without a delay, the administration curve, the post-administration curve, and the total curve with a delay between administration of an oral dose of Cr or Yb and its entry into the compartment, in horses offered orchardgrass/alfalfa hay and fat-and-fiber (FF) supplement using Cr (Diet 3Cr), or Yb (Diet 3Yb), or orchardgrass/alfalfa hay and sugar-and-starch supplement using Cr (Diet 4Cr), or Yb (Diet 4Yb), in Experiment 2	78
24. Fits of data to a one-compartment model of fecal kinetics without a delay, the administration curve, the post-administration curve, and the total curve with a delay between administration of an oral dose of Cr and its entry into the compartment, in horses offered orchardgrass/alfalfa hay and sugar-and-starch supplement in Experiment 2	79
25. Fits of data to a one-compartment model of fecal kinetics without a delay, the administration curve, the post-administration curve, and the total curve with a delay between administration of an oral dose of Yb and its entry into the compartment, in horses offered orchardgrass/alfalfa hay and sugar-and-starch supplement in Experiment 2	80
26. Estimates of fit of individual fecal chromium concentration data to a one-compartment model, model parameters, and calculated variables in horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3Cr) in Experiment 2	81
27. Estimates of fit of individual fecal chromium concentration data to a one-compartment model, model parameters, and calculated variables in horses offered orchardgrass/alfalfa hay and sugar-and-starch supplement (Diet 4Cr) in Experiment 2	81

28. Total collection fecal output (FO_{TC} , kg/d DM), and estimates of fecal output (FO_{CA} , kg/d DM) from the one-compartment model using fecal grab data for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (OGFF, Diet 3Cr) or sugar-and-starch supplement (OGSS, Diet 4Cr), with chromium as the external marker, in Experiment 2	82
29. Total collection fecal output (FO_{TC} , kg/d DM), and estimates of fecal output (FO_{CA} , kg/d DM) from the one-compartment model using fecal grab data for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (OGFF, Diet 3Yb) or sugar-and-starch supplement (OGSS, Diet 4Yb), with ytterbium as the external marker, in Experiment 2	83
30. Turnover times (TT, h) from the chromium one-compartment model, for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (OGFF, Diet 3Cr), and orchardgrass/alfalfa hay and sugar-and-starch supplement (OGSS, Diet 4Cr) in Experiment 2	84
31. Turnover times (TT, h) from the ytterbium one-compartment model, for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (OGFF, Diet 3Yb), and orchardgrass/alfalfa hay and sugar-and-starch supplement (OGSS, Diet 4Yb) in Experiment 2	85
32. Prefecal mass (PFM, kg DM) from the chromium one-compartment model, for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (OGFF, Diet 3Cr), and orchardgrass/alfalfa hay and sugar-and-starch supplement (OGSS, Diet 4Cr) in Experiment 2	86
33. Prefecal mass (PFM, kg DM) from the ytterbium one-compartment model, for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (OGFF, Diet 3Yb), and orchardgrass/alfalfa hay and sugar-and-starch supplement (OGSS, Diet 4Yb) in Experiment 2	87
34. Fecal recovery of chromium (R_{CR} , %) for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3Cr), and orchardgrass/alfalfa hay and sugar-and-starch supplement (Diet 4Cr) in Experiment 2	88
35. Fecal recovery of ytterbium (R_{YB2} , %) for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3Yb), and orchardgrass/alfalfa hay and sugar-and-starch supplement (Diet 4Yb) in Experiment 2	88
36. Fecal dry matter (DM, % wet weight), of horses offered orchardgrass/alfalfa hay (Diet 1), tall fescue/alfalfa hay (Diet 2), orchardgrass alfalfa hay and fat-and-fiber supplement (Diet 3), and orchardgrass alfalfa hay and sugar-and-starch supplement (Diet 4), in Experiment 1 and 2	89

List of Figures

<u>Figure</u>	<u>Page</u>
1. A one-compartment model of the prefecal mass (PFM, kg), or mixing compartment, sampled by feces and fecal output (FO, kg/d), with a delay (d , d) between oral administration of Cr or Yb dose (*) and the entry of this Cr or Yb into the PFM. The fecal Cr or Yb concentrations (mg/kg DM) at time t (d), C_t , rise to an asymptotic value, C_a , and can be used to determine a single rate constant, k (d^{-1}): $C_t = C_a - C_a \cdot e^{-k(t-d)}$	90
2. Total collection (C) of DMD and corresponding marker estimates (M) of DMD predicted by yttrium marker dilution, were correlated for horses offered orchardgrass/alfalfa hay (Diet 1) in Experiment 1	91
3. Total collection (C) of DMD and corresponding marker estimates (M) of DMD predicted by yttrium marker dilution, were correlated for horses offered tall fescue/alfalfa hay (Diet 2) in Experiment 1	92
4. Mean daily fecal concentrations of Cr, C_t , for horses offered orchardgrass/alfalfa hay (Diet 1a) are plotted against time, and the data are fit to a one-compartment model using the total collection data	93
5. Mean daily fecal concentrations of Cr, C_t , for horses offered orchardgrass/alfalfa hay (Diet 1b) are plotted against time, and the data are fit to a one-compartment model using the fecal grab data	94
6. Mean daily fecal concentrations of Cr, C_t , for horses offered tall fescue/alfalfa hay (Diet 2a) are plotted against time, and the data are fit to a one-compartment model using the total collection data	95
7. Mean daily fecal concentrations of Cr, C_t , for horses offered tall fescue/alfalfa hay (Diet 2b) are plotted against time, and the data are fit to a one-compartment model using the fecal grab data	96
8. Linear relationship between total collection (C) fecal output and corresponding marker estimates (M) using the total collection data, for horses offered orchardgrass/alfalfa hay (Diet 1a) in Experiment 1	97
9. Linear relationship between total collection (C) fecal output and corresponding marker estimates (M) using the total collection data, for horses offered tall fescue/alfalfa hay (Diet 2a) in Experiment 1	98

10. Linear relationship between total collection (C) fecal output and corresponding marker estimates (M) using the fecal grab data, for horses offered orchardgrass/alfalfa hay (Diet 1b) in Experiment 1	99
11. Linear relationship between total collection (C) fecal output and corresponding marker estimates (M) using the fecal grab data, for horses offered tall fescue/alfalfa hay (Diet 2b) in Experiment 1	100
12. Total collection (C) fecal output and corresponding marker estimates (M) predicted by chromium marker dilution and using the fecal grab data, were correlated for horses offered tall fescue/alfalfa hay (Diet 2b) in Experiment 1	101
13. Diurnal variation in fecal concentration (mg/kg, DM) of chromium for individual horse fecal grab samples collected on d 8 of dosing, for horses offered orchardgrass/alfalfa hay (Diet 1) in Experiment 1	102
14. Total collection (C) of DMD and corresponding marker estimates (M) of DMD predicted by yttrium marker dilution, were correlated for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3) in Experiment 2	103
15. Total collection (C) of DMD and corresponding marker estimates (M) of DMD predicted by yttrium marker dilution, were correlated for horses offered orchardgrass/alfalfa hay and sugar-and-starch supplement (Diet 4) in Experiment 2	104
16. Mean daily fecal concentrations of Cr, Ct, for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3Cr) are plotted against time, and the data are fit to a one-compartment model	105
17. Mean daily fecal concentrations of Cr, Ct, for horses offered orchardgrass/alfalfa hay and sugar-and-starch supplement (Diet 4Cr) are plotted against time, and the data are fit to a one-compartment model	106
18. Mean daily fecal concentrations of Yb, Ct, for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3Yb) are plotted against time, and the data are fit to a one-compartment model	107
19. Mean daily fecal concentrations of Yb, Ct, for horses offered orchardgrass/alfalfa hay and sugar-and-starch supplement (Diet 4Yb) are plotted against time, and the data are fit to a one-compartment model	108

20. Linear relationship between total collection (C) fecal output and corresponding marker estimates (M) predicted by chromium marker dilution, for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3Cr) in Experiment 2	109
21. Total collection (C) fecal output and corresponding marker estimates (M) predicted by chromium marker dilution, were correlated for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3Cr) in Experiment 2	110
22. Linear relationship between total collection (C) fecal output and corresponding adjusted marker estimates (M), predicted by chromium marker dilution for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3Cr) in Experiment 2	111
23. Total collection (C) fecal output and corresponding adjusted marker estimates (M) predicted by chromium marker dilution, were correlated for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3Cr) in Experiment 2	112
24. Linear relationship between total collection (C) fecal output and corresponding marker estimates (M) predicted by chromium marker dilution, for horses offered orchardgrass/alfalfa hay and sugar-and-starch supplement (Diet 4Cr), in Experiment 2	113
25. Linear relationship between total collection (C) fecal output and corresponding marker estimates (M) predicted by ytterbium marker dilution, for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3Yb), in Experiment 2	114
26. Total collection (C) fecal output and corresponding adjusted marker estimates (M) predicted by ytterbium marker dilution, were correlated for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3Yb) in Experiment 2	115
27. Linear relationship between total collection (C) fecal output and corresponding adjusted marker estimates (M), predicted by ytterbium marker dilution for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3Yb) in Experiment 2	116
28. Total collection (C) fecal output and corresponding adjusted marker estimates (M) predicted by ytterbium marker dilution, were correlated for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3Yb) in Experiment 2	117

29. Linear relationship between total collection (C) fecal output and corresponding marker estimates (M), predicted by ytterbium marker dilution for horses offered orchardgrass/alfalfa hay and sugar-and-starch supplement (Diet 4Yb) in Experiment 2	118
30. Linear relationship between prefecal mass (kg DM) predicted by chromium marker dilution (Cr), and prefecal mass predicted by ytterbium marker dilution (Yb) for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diets 3Cr and 3Yb) in Experiment 2	119
31. Linear relationship between prefecal mass (kg DM) predicted by chromium marker dilution (Cr), and prefecal mass predicted by ytterbium marker dilution (Yb) for horses offered orchardgrass/alfalfa hay and sugar-and-starch supplement (Diets 4Cr and 4Yb) in Experiment 2	120
32. Diurnal variation in fecal concentration (mg/kg, DM) of chromium for individual horse fecal grab samples collected on d 8 of dosing, for horses offered orchardgrass/alfalfa hay and sugar-and-starch supplement (Diet 4Cr), in Experiment 2	121
33. Diurnal variation in fecal concentration (mg/kg, DM) of ytterbium for individual horse fecal grab samples collected on d 8 of dosing, for horses offered orchardgrass/alfalfa hay and sugar-and-starch supplement (Diet 4Yb), in Experiment 2	122
34. Linear relationship between dry matter percentage of feces (DM %) and corresponding turnover times predicted by chromium marker dilution, for horses offered orchardgrass/alfalfa hay (Diet 1), in Experiment 1, and horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3Cr), in Experiment 2	123
35. Dry matter percentage of feces (DM %) and corresponding turnover times predicted by chromium marker dilution, were correlated for horses offered orchardgrass/alfalfa hay (Diet 1), in Experiment 1, and for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3Cr), in Experiment 2	124
36. Linear relationship between dry matter percentage of feces (DM %) and corresponding turnover times predicted by chromium marker dilution, for horses offered orchardgrass/alfalfa hay (Diet 1), in Experiment 1, and horses offered orchardgrass/alfalfa hay and sugar-and-starch supplement (Diet 4Cr), in Experiment 2	125

37. Dry matter percentage of feces (DM %) and corresponding turnover times predicted by chromium marker dilution, were correlated for horses offered orchardgrass/alfalfa hay (Diet 1), in Experiment 1, and for horses offered orchardgrass/alfalfa hay and sugar-and-starch supplement (Diet 4Cr), in Experiment 2	126
38. Linear relationship between dry matter percentage of feces (DM %) and corresponding turnover times predicted by ytterbium marker dilution, for horses offered orchardgrass/alfalfa hay (Diet 1), in Experiment 1, and horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3Yb), in Experiment 2	127
39. Dry matter percentage of feces (DM %) and corresponding turnover times predicted by ytterbium marker dilution, were correlated for horses offered orchardgrass/alfalfa hay (Diet 1), in Experiment 1, and for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3Yb), in Experiment 2	128
40. Linear relationship between dry matter percentage of feces (DM %) and corresponding turnover times predicted by ytterbium marker dilution, for horses offered orchardgrass/alfalfa hay (Diet 1), in Experiment 1, and horses offered orchardgrass/alfalfa hay and sugar-and-starch supplement (Diet 4Yb), in Experiment 2	129
41. Dry matter percentage of feces (DM %) and corresponding turnover times predicted by ytterbium marker dilution, were correlated for horses offered orchardgrass/alfalfa hay (Diet 1), in Experiment 1, and for horses offered orchardgrass/alfalfa hay and sugar-and-starch supplement (Diet 4Yb), in Experiment 2	130
42. Linear relationship between mean percentage dry matter of feces (DM %) and corresponding mean turnover times predicted by chromium marker dilution, for horses offered hay only in Experiment 1, and hay and supplement in Experiment 2	131

List of Appendix Tables

<u>Appendix Table</u>	<u>Page</u>
1. Dietary treatments for horses offered orchardgrass/alfalfa hay (Diet 1) or tall fescue/alfalfa hay (Diet 2) in Experiment 1	132
2. Nutrient composition on a DM basis of orchardgrass/alfalfa hay (Diet 1) and tall fescue/alfalfa hay (Diet 2) in Experiment 1	133
3. Dietary treatments for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3) or orchardgrass/alfalfa hay and sugar-and-starch supplement (Diet 4) in Experiment 2	134
4. Nutrient composition on a DM basis of orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3) or orchardgrass/alfalfa hay and sugar-and-starch supplement (Diet 4) in Experiment 2	135
5. Ingredient composition (%) of the fat-and-fiber (FF) supplement offered in Experiment 2	136
6. Ingredient composition of the chromium granola bars (Cr _{GB}) offered to horses in Experiment 1 and 2	137
7. Dry matter intake (DMI, kg/d), total fecal output (FO, kg/d), and total collection DMD (D _{TC} , %) for horses offered orchardgrass/alfalfa hay (Diet 1) and tall fescue/alfalfa hay (Diet 2) in Experiment 1	137
8. Fecal concentrations (mg/kg) of yttrium for horses offered orchardgrass/alfalfa hay (Diet 1) and tall fescue/alfalfa hay (Diet 2) in Experiment 1	138
9. Mean daily fecal concentrations (mg/kg, DM) of chromium for horses offered orchardgrass/alfalfa hay (Diet 1a) and tall fescue/alfalfa hay (Diet 2a) using total collection data in Experiment 1	139
10. Mean daily fecal concentrations (mg/kg, DM) of chromium for horses offered orchardgrass/alfalfa hay (Diet 1b) and tall fescue/alfalfa hay (Diet 2b) using fecal grab data in Experiment 1	140
11. Individual horse daily fecal concentrations (mg/kg, DM) of chromium for horses offered orchardgrass/alfalfa hay (Diet 1a) using total collection data in Experiment 1	141

12. Individual horse daily fecal concentrations (mg/kg, DM) of chromium for horses offered tall fescue/alfalfa hay (Diet 2a) using total collection data in Experiment 1	142
13. Individual horse daily fecal concentrations (mg/kg, DM) of chromium for horses offered orchardgrass/alfalfa hay (Diet 1b) using fecal grab data in Experiment 1	143
14. Individual horse daily fecal concentrations (mg/kg, DM) of chromium for horses offered tall fescue/alfalfa hay (Diet 2b) using fecal grab data in Experiment 1	144
15. Fits of data to a one-compartment model of fecal kinetics without a delay, the administration curve, the post-administration curve, and the total curve with a delay between administration of an oral dose of Cr and its entry into the compartment, in horses offered orchardgrass/alfalfa hay using fecal grab data in Experiment 1	145
16. Fits of data to a one-compartment model of fecal kinetics without a delay, the administration curve, the post-administration curve, and the total curve with a delay between administration of an oral dose of Cr and its entry into the compartment, in horses offered tall fescue/alfalfa hay using total collection data in Experiment 1	146
17. Fits of data to a one-compartment model of fecal kinetics without a delay, the administration curve, the post-administration curve, and the total curve with a delay between administration of an oral dose of Cr and its entry into the compartment, in horses offered tall fescue/alfalfa hay using fecal grab data in Experiment 1	147
18. Estimates of fit of individual fecal chromium concentration data to a one-compartment model, model parameters, and calculated variables in horses offered orchardgrass/alfalfa hay using fecal grab data (Diet 1b) in Experiment 1	148
19. Estimates of fit of individual fecal chromium concentration data to a one-compartment model, model parameters, and calculated variables in horses offered tall fescue/alfalfa hay using total collection data (Diet 2a) in Experiment 1	149
20. Estimates of fit of individual fecal chromium concentration data to a one-compartment model, model parameters, and calculated variables in horses offered tall fescue/alfalfa hay using fecal grab data (Diet 2b) in Experiment 1	150

21. Fecal concentrations (mg/kg DM) of chromium for horses offered orchardgrass/alfalfa hay (Diet 1a) and tall fescue/alfalfa hay (Diet 2a) using total collection data in Experiment 1	151
22. Fecal concentrations (mg/kg DM) of chromium for horses offered orchardgrass/alfalfa hay (Diet 1b) and tall fescue/alfalfa hay (Diet 2b) using fecal grab data in Experiment 1	152
23. Dry matter intake (DMI, kg/d), total fecal output (FO, kg/d), and total collection DMD (D_{TC} , %) for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3) and orchardgrass/alfalfa hay and sugar-and-starch supplement (Diet 4) in Experiment 2	153
24. Fecal concentrations (mg/kg DM) of yttrium for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3) and orchardgrass/alfalfa hay and sugar-and-starch supplement (Diet 4) in Experiment 2	154
25. Fecal concentrations (mg/kg DM) of ytterbium for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3) and orchardgrass/alfalfa hay and sugar-and-starch supplement (Diet 4) in Experiment 2	154
26. Mean daily fecal concentrations (mg/kg, DM) of chromium for horses offered orchardgrass/alfalfa and fat-and-fiber supplement (Diet 3Cr) and orchardgrass/alfalfa hay and sugar-and-starch supplement (Diet 4Cr) in Experiment 2	155
27. Mean daily fecal concentrations (mg/kg, DM) of ytterbium for horses offered orchardgrass/alfalfa and fat-and-fiber supplement (Diet 3Yb) and orchardgrass/alfalfa hay and sugar-and-starch supplement (Diet 4Yb) in Experiment 2	156
28. Individual horse daily fecal concentrations (mg/kg, DM) of chromium for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3Cr) in Experiment 2	157
29. Individual horse daily fecal concentrations (mg/kg, DM) of ytterbium for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3Yb) in Experiment 2	158
30. Individual horse daily fecal concentrations (mg/kg, DM) of chromium for horses offered orchardgrass/alfalfa hay and sugar-and-starch supplement (Diet 4Cr) in Experiment 2	159
31. Individual horse daily fecal concentrations (mg/kg, DM) of ytterbium for horses offered orchardgrass/alfalfa hay and sugar-and-starch supplement (Diet 4Yb) in Experiment 2	160

32. Fits of data to a one-compartment model of fecal kinetics without a delay, the administration curve, the post-administration curve, and the total curve with a delay between administration of an oral dose of Cr and its entry into the compartment, in horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement in Experiment 2	161
33. Fits of data to a one-compartment model of fecal kinetics without a delay, the administration curve, the post-administration curve, and the total curve with a delay between administration of an oral dose of Yb and its entry into the compartment, in horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement in Experiment 2	162
34. Estimates of fit of individual fecal ytterbium concentration data to a one-compartment model, model parameters, and calculated variables in horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3Yb) in Experiment 2	163
35. Estimates of fit of individual fecal ytterbium concentration data to a one-compartment model, model parameters, and calculated variables in horses offered orchardgrass/alfalfa hay and sugar-and-starch supplement (Diet 4Yb) in Experiment 2	164
36. Fecal concentrations (mg/kg DM) of chromium for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3Cr) and orchardgrass/alfalfa hay and sugar-and-starch supplement (Diet 4Cr) in Experiment 2	165
37. Fecal concentrations (mg/kg DM) of ytterbium for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3Yb) and orchardgrass/alfalfa hay and sugar-and-starch supplement (Diet 4Yb) in Experiment 2	165
38. Diurnal variation in fecal concentrations (mg/kg DM) of chromium for individual horse fecal grab samples collected on d 8 of dosing, for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3Cr) in Experiment 2	166
39. Diurnal variation in fecal concentrations (mg/kg DM) of chromium for individual horse fecal grab samples collected on d 8 of dosing, for horses offered orchardgrass/alfalfa hay and sugar-and-starch supplement (Diet 4Cr) in Experiment 2	167
40. Diurnal variation in fecal concentrations (mg/kg DM) of ytterbium for individual horse fecal grab samples collected on d 8 of dosing, for horses offered orchardgrass/alfalfa hay and fat-and-fiber supplement (Diet 3Yb) in Experiment 2	168

41. Diurnal variation in fecal concentrations (mg/kg DM) of ytterbium for individual horse fecal grab samples collected on d 8 of dosing, for horses offered orchardgrass/alfalfa hay and sugar-and-starch supplement (Diet 4Yb) in Experiment 2	169
--	-----

