

# HORSE MANURE CHARACTERISTICS LITERATURE AND DATABASE REVIEW

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## ABSTRACT

The purpose of this study was to summarize available information on nutrient excretion by horses from as many sources as possible. Values for amounts and characteristics of fresh manure (feces and urine, as excreted) were obtained from published nutrition study values for nitrogen (N), phosphorus (P) and potassium (K). Only data from horses 18 months of age or older were used. Data were separated into values obtained from non-working (sedentary) and working (exercised) horses. There were insufficient data on growing horses, pregnant mares and lactating mares to evaluate nutrient excretion in these groups. Estimates of dry matter excretion and total manure were calculated using information from the National Research Council "Nutrient Requirements of Horses" and other sources. Equations for estimating N, P, and K excretion were developed from studies reporting nutrient intake and nutrient excretion on a body weight basis. Representative values were calculated using the equations for estimating nutrient excretion for horses weighing 400 to 600 kg.

**KEYWORDS** equine, manure, nutrient, excretion

## INTRODUCTION

The purpose of this review was to develop equations to estimate horse manure characteristics based on studies that have measured the amounts of nutrients excreted by mature horses fed known diets. This review is part of a project on National Standards for Estimating Manure Nutrient Excretion Based Upon Animal Feed Program. The American Society of Agricultural Engineers (ASAE), Federation of Animal Science Societies (FASS), and Natural Resources Conservation Service (NRCS), initiated this joint effort to review existing standards and develop new, feed program-based models for estimating manure and nutrient excretion. Standard manure characteristics published by the NRCS, ASAE and Midwest Plan Service (MWPS) commonly have been used for this purpose. Project work groups were asked to recommend standards for two topics reported here:

1. As Excreted - Feed Intake Summary: Characteristics of excreted manure based upon a mass balance approach using estimates of feed intake and animal retention and calculation of excretion by difference or other appropriate relationships.
2. As Excreted – Average Summary: A review and modification of the existing ASAE D384.1 tables (ASAE, 2001) to define average characteristics of excreted manure for typical feed programs.

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## METHODS

### Dry Matter and Total Manure Excretion

Dry matter excretion and total manure production is related to dry matter intake (DMI) and dry matter digestibility (DMD). To estimate DMI, information on digestible energy requirements, dietary digestible energy density, and forage-to-concentrate ratios from the Nutrient Requirements of Horses (NRC, 1989) was used.

This NRC report makes recommendations for energy intakes and average energy concentrations in the total diet. Using these values, the following DMI (in kg/d) can be calculated with the following equations if body weight (BW) (in kg) is known:

$$\text{DMI}_{\text{Sedentary}} = \frac{0.03BW + 1.4}{2.0}$$

$$\text{DMI}_{\text{Light Work}} = \frac{1.25(0.03BW + 1.4)}{2.45}$$

$$\text{DMI}_{\text{Moderate Work}} = \frac{1.5(0.03BW + 1.4)}{2.65}$$

$$\text{DMI}_{\text{Intense Work}} = \frac{2.0(0.03BW + 1.4)}{2.85}$$

Once DMI is predicted, fecal dry matter excretion may be estimated if the digestibility of the diet is known. Dry matter digestibility (DMD) is greatly influenced by the proportion of forage in the diet. Typically, diets for horses at maintenance (sedentary) contain higher levels of forage than diets for horses performing work. For the purposes of this review, the following forage-to-concentrate ratios were used for horses performing different levels of work (NRC, 1989):

Mature Horses at Maintenance: 100% forage, 0% concentrate diet

Mature Horses in Light Work: 65% forage, 35% concentrate

Mature Horses in Moderate Work: 50% forage, 50% concentrate

Mature Horses in Intense Work: 35% forage, 65% concentrate

DMD of forages may range from 45% to 65% depending upon stage of maturity at cutting and variety. Typical estimates for DMD of grass hay are 50-55% and for legume hay 60-65%. DMD of concentrates will vary from 70 to 80%. The following assumptions were used in estimating DMD for diets with varying forage-to-concentrate ratios:

Dry matter digestibility of 100% forage diets = 57.5 %

Dry matter digestibility of 65% forage: 35% concentrate diets = 64 %

Dry matter digestibility of 50% forage: 50% concentrate diets = 66 %

Dry matter digestibility of 35% forage: 65% concentrate diets = 69 %

### Estimating Nitrogen, Phosphorus and Potassium Excretion

A literature search of refereed and non-refereed publications for data pertaining to excretion of nitrogen, phosphorus, calcium, magnesium and potassium excretion by horses was performed. Excretion values included losses in urine and feces and did not account for other routes (sweat, respiration, hair shedding, etc). Twenty-seven useful data sets were found. To be useful, each study had to meet the following criteria:

- Provide information on the age of the horses or ponies used;
- Describe whether the animals were subjected to any type of exercise program;

- Describe the daily amount of nutrient consumed per kg of body weight OR total amount of nutrient consumed per day and body weight;
- Describe the amount of nutrient excreted per day in urine and feces per kg body weight OR the total amount of nutrient excreted and the body weight of the horse.

Only data derived from horses of at least 18 months of age were used. Insufficient data were available to estimate excretion from rapidly growing horses, pregnant mares or lactating mares.

Only one study reported individual animal data. Therefore only values for mean intake and mean excretion of the specific nutrient were used. Each mean typically represented data collected from several animals subjected to a particular treatment over a multiple-day sampling period. When a study was designed to compare nutrient utilization from different diets, mean values for each diet were used. Some studies were designed to evaluate the effect of physical conditioning on nutrient utilization and retention by horses, sometimes in combination with dietary treatments. For these studies, mean values for each treatment in each period were used. Some studies supplied only one or two data points while others contained more than twenty data points.

Data were summarized in two sets for each nutrient: sedentary horses (no regular forced exercise) and exercised horses (exercised daily or several times a week during the study). For each nutrient, data sets contained values for ponies and horses. Therefore, all intake and excretion values were expressed on a body weight basis (g or mg/kg BW). This report contains the results of preliminary assessment of the linear relationships between intake and excretion.

## RESULTS AND DISCUSSION

The following tables and equations estimate horse nutrient excretion based upon feed intake, feed nutrient concentration, and animal level of exercise. Recommended average (and range) excretion estimates are provided for nitrogen, phosphorus and potassium. These values are intended to replace current ASAE excretion estimates as being more representative of horse feeding practices at the time of this project. Table 1 presents the estimated values for DMI, DMD and fecal dry matter determined using the assumptions described in the methods.

Total manure output is the sum of urine output and fecal output. The previous ASAE (2001) estimated daily urine output at 5 kg/d for a 500 kg horse. Slightly higher values of 6-6.5 kg/d were found in a recent study (O'Connor, personal communication). Using exercising horses, Willard (1971) reported urine outputs of 8 to 10 kg/d per horse. For this review, urine output was estimated at 1.6 kg/100 kg BW. Daily wet feces weight was calculated from estimated dry matter excretion in the feces using a moisture content of 80%. Fecal moisture can range from 75 to 82%, depending upon feed composition and feed processing (Pagan and Jackson, 1991; Warren, 2000; O'Connor, personal communication). The amount of total solids excreted was calculated using total daily manure production and an estimated dry matter content of the daily manure (feces + urine) of 15%. Representative values for total manure and total solids excreted per day are presented in Table 1. The DMI and DMD values used to calculate fecal dry matter excretion are shown in Table 2.

Using the available information on nitrogen, phosphorus and potassium intake and excretion, the following equations for estimating daily nitrogen, phosphorus and potassium excretion were developed. For nitrogen, different equations should be used to estimate excretion by working and non-working horses. For phosphorus and potassium, the same equation may be used as there were no significant differences between sedentary and exercised horses at the 5% level.

### Nitrogen Excretion (mg/kg BW)

$$\text{Sedentary horses: } N_{\text{out}} = 55.4 + 0.586 \times N_{\text{in}} \quad (R^2 = 0.76) \quad (1a)$$

$$\text{Exercised horses: } N_{\text{out}} = 42.9 + 0.492 \times N_{\text{in}} \quad (R^2 = 0.94) \quad (1b)$$

Phosphorus Excretion (mg/kg BW)  
 Sedentary or exercised horses:  $P_{out} = 4.56 + 0.793 \times P_{in}$  ( $R^2 = 0.85$ ) (2)

Potassium Excretion (mg/kg BW)  
 Sedentary or exercised horses:  $K_{out} = 19.4 + 0.673 \times K_{in}$  ( $R^2 = 0.62$ ) (3)

Definition of Variables

$N_{in}$  = Nitrogen intake (mg/kg BW);  $N_{out}$  = Nitrogen excretion;  
 $P_{in}$  = Phosphorus intake (mg/kg BW);  $P_{out}$  = Phosphorus excretion;  
 $K_{in}$  = Potassium intake (mg/kg BW);  $K_{out}$  = Potassium excretion;  
 BW = Body weight (kg)

The nitrogen data included 46-paired values (intake and excretion); 32 for sedentary animals and 14 for exercised animals. Across the studies nitrogen intake ranged from 130 to 530 mg N/kg BW. The National Research Council (NRC) Subcommittee on Horse Nutrition (1989) recommended crude protein intakes containing approximately 200 mg N/kg BW for mature horses at maintenance (sedentary) and 420 mg N/kg BW for horses performing regular intense exercise (such as racing). Survey studies of racetrack feeding practices indicate that levels of crude protein exceeding the NRC recommendations are sometimes fed; thus, the range of intakes used here probably represents practical equine diets. For phosphorus, a total of 129-paired observations were used. Phosphorus intakes ranged from 19 mg P/kg BW per day to 200 mg P/kg BW per day. The NRC Subcommittee on Horse Nutrition (1989) recommended intakes of approximately 28 mg P/kg BW for mature horses at maintenance and 58 mg P/kg BW for horses performing regular intense exercise. Surveys of feeding practices at racetracks indicate that some horses may consume diets containing approximately 120 mg P/kg BW. Therefore the range of values used in this report represents levels of P in common equine diets. There has been limited work characterizing total potassium excretion in horses. For potassium, only 28-paired values were available with intakes ranging from 50 to 404 mg/kg BW. The amount of potassium recommended by the NRC Subcommittee on Horse Nutrition (1989) was 50 mg/kg BW in horses at maintenance and 100 mg/kg BW in horses performing intense work. Practical horse diets often contain levels of potassium much higher than the NRC recommendations because potassium concentrations in common forages typically range between 1 and 2% on a dry matter basis, and higher levels are not unusual. Forage will constitute the majority of the diet of a horse at maintenance and may comprise 50% or more of the diet of horses performing intense exercise.

Table 1 contains the estimated daily excretion of nitrogen, phosphorus and potassium when horses are fed diets containing nutrient levels recommended by the NRC Subcommittee on Horse Nutrition (NRC, 1989). Table 2 provides information on expected intakes. Representative values are given for a 500 kg horse, with the range representing body weights from 400 to 600 kg. The effect of exercise on nutrient output was found to be significant at the 5% level for nitrogen only. Therefore, in order to estimate nitrogen excretion by a 500 kg horse, equation (1a) was used for horses performing no daily exercise, and equation (1b) was used for horses performing light, moderate, or intense work. Phosphorus and potassium excretion values were estimated from equations (2) and (3) respectively, for horses performing no daily exercise, light, moderate or intense work. The range of potassium intakes recommended by the NRC (1989) for exercising horses is much lower than the levels fed in the studies reviewed here. It should also be noted that typical potassium intakes for horses consuming practical forage diets will be much higher than NRC (1989) recommendations (see footnotes in Table 1 and 2).

Table 1. Estimated manure excretion characteristics for horses based on performance and feed program measures. Moisture is 15% w.b. See footnotes A-E.

Horse Type and Exercise Grouping	Total Manure kg/d-animal	Total solids Kg/d- animal	Nitrogen kg/d- animal	P kg/d-animal	K kg/d-animal	Ca kg/ d-animal	Mg kg / d-animal
Sedentary-500 kg	25.5	3.8	.089	.013	.027	.023	.009
Range 400-600 kg	20.9-30.1	3.1-4.5	.073- .106	.011-.016	.021-.032	.019-.028	.007-.010
Light exercise-500 kg	23.0	3.4	.086	.017	.031	.017	.010
Range 400-600 kg	18.9-27.6	2.8-4.1	.070-.102	.015-.019	.025-.037	.014-.021	.008-.011
Moderate exercise- 500 kg	24.0	3.6	.099	.019	.035	.021	.011
Range 400-600 kg	19.4-28.1	2.9-4.2	.081-.148	.015-.023	.029-.044	.018-.025	.009-.013
Intense exercise -500 kg	26.0	3.9	.125	.025	.043	.029	.013
Range 400-600 kg	20.9-30.6	3.1-4.5	.102-.148	.020-.030	.041-.051	.024-.034	.010-.015

Table 2. Dietary and performance assumptions for estimated horse manure excretion characteristics. See footnotes A-E.

Horse Type and Exercise Grouping	Average Live Weight (kg)	Dietary Assumptions					Ca (g/d)	Mg (g/d)
		Dry Matter Intake (% of average body weight)	Dry Matter Digestibility	Crude Protein (gm/day)	P (gm/day)	K (gm/day)		
Sedentary-	500	1.6	57.5 %	656	14	25	20	7.5
Range	400-600	1.6-1.7	57.5 %	536-776	11-17	20-30	16-24	6-9
Light exercise-	500	1.7	64 %	820	18	31	25	9.4
Range	400-600	1.7-1.8	64 %	670-970	15-21	26-37	20-30	8-11
Moderate exercise-	500	1.8-1.9	66 %	984	21	37	30	11.3
Range	400-600	1.9	66 %	804-1164	17-25	31-44	25-36	9-13
Intense exercise	500	2.3	69 %	1312	29	50	40	15.1
Range	400-600	2.3-2.4	69 %	1072-1552	23-34	41-59	33-47	12-18

<sup>A</sup> These values apply to horses 18 months of age or older that are not pregnant or lactating. The representative number applies to 500 kg horses and the range represents horses from 400 to 600 kg. Under type of horse, classifications are made on amount of regular exercise imposed on horses. “Sedentary” would apply to horses not receiving any imposed exercise; “Light” would include horses ridden at low intensities for a few hours per week, such as pleasure riding; “Moderate” would include horses used for showing, lower level combined training, and ranch work. “Intense” would include race training, polo, and upper level combined training.

<sup>B</sup> When the forage component of the ration is composed of legume hay, actual nitrogen intakes will be higher than those given here. If legume hay contains 17% CP on a dry matter basis, expected N intake and excretion, respectively would be: Sedentary, 223 and 158 g; Light, 193 and 117 g; Moderate, 216 and 128 g; Intense, 253 and 146 g.

<sup>C</sup> Intakes of potassium by horses receiving typical forage based diets would be expected to be higher because of high levels of potassium in common forages. If forage contains 1.5% K on a dry matter basis, expected K intake and excretion, respectively would be: Sedentary, 123 and 93 g; Light, 90 g and 70 g; Moderate, 85 g and 67 g; Intense, 85 g and 67g.

<sup>D</sup> When the forage component of the ration is composed of legume hay, actual calcium intakes would be much higher than those given here. If legume hay contains 1.2% calcium on a dry matter basis, expected Ca intake and excretion, respectively, would be: Sedentary, 98 g and 62 g; Light, 76 g and 58 g; Moderate exercise, 75 g and 58 g; and Intense, 75 g and 58g.

<sup>E</sup> When the forage component of the ration is composed of legume hay, actual magnesium intakes would be much higher than those given here. If legume hay contains .35% magnesium on a dry matter basis, expected Mg intake and excretion, respectively, would be: Sedentary, 33 g and 23 g; Light, 25 g and 18 g; Moderate exercise, 23 g and 17 g; and Intense Exercise, 23 g and 17 g.

## CONCLUSIONS

Nutrient characteristics of horse manure were estimated based on at least 33 published reports providing information for mature horses that were fed known diets. Dry matter intake and total manure excretion were also estimated. Only studies with information on the age and body weight of equine, description of any exercise program, and nutrient consumption and excretion amounts were used. Only data from horses at least 18-months old were evaluated. Insufficient data were available to provide estimates for other types of horses.

Equations were developed for estimating the daily excretion of nitrogen, phosphorus and potassium based on horse body weight and nutrient intake. Nitrogen excretion was dependent on the amount of imposed exercise the horse received. Potassium and phosphorus excretion were not affected by exercise level. Intake of potassium by horses receiving typical forage-based diets would be higher than expected due to high levels of potassium in common forages. Likewise, nitrogen intake by horses fed a diet composed of legume hay will be higher than values suggested by the National Research Council's guidelines on Nutrient Requirements of Horses.

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