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Analysis of current equine feeding practices in the Netherlands and identification of potential nutrient leaching and environmental contamination factors

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ABSTRACT

The aim of this study was to estimate the potential for nutrient leaching based on current feeding practices of horses in the Netherlands. An online survey of horse owners collected data on the demographics of the horses (n = 274) and feeding practices. The median age was 8 years, the majority being warmblood and geldings with a mean bodyweight of 542.4 ± 101.9 kg. Most horses (85 %) had access to a limited area of pasture (<200m^2 per horse), with a median grazing time of 10 hours. Grass hay was the predominant conserved forage offered (77 %) within diets. Concentrate feeds were provided to most horses (93.8 %) as well as the dietary supplements (80 %). The majority of the horses were offered high levels of metabolizable energy (ME) (90 %), starch (mean 2.4 ± 0.8 g/kg bw) and sugar intake (mean 1.4 ± 1.2 g/kg bw) compared to NRC recommendations. The estimated potential nitrogen excretion per horse per day was 228 ± 134 g, or 8.47 kg of nitrogen per ton of manure. Consequently, the estimated daily fecal excretion rates of microminerals for each horse were as follows: Copper (Cu) at 141.0 ± 151.3 mg, Zinc (Zn) at 593.1 ± 504.4 mg, Manganese (Mn) at 957 ± 541.2 mg, and Cobalt (Co) at 2.3 ± 3.5 mg. The analysis indicated that many equine diets in the Netherlands offered excess ME, CP and the minerals Cu, Zn, Mn and Co. To mitigate these concerns, it is crucial to promote sustainable feeding practices and better educate horse owners.

1. Introduction

Equine nutrition and diet composition are of paramount importance, not only for the well-being of horses but also for the environment. The choices we make in feeding our horses can have significant implications for mineral pollution and overall sustainability. Regrettably, many equine diets are still rooted in tradition and are primarily focused on optimizing horse performance, often overlooking their environmental footprint. This is particularly relevant today, as the world grapples with growing environmental concerns. It's worth noting that the European Union is home to approximately 6 million horses, some of which are managed within relatively small geographical regions, compounding issues associated with management and nutrient leaching [1]. There is a pressing need to reevaluate our approach to horse nutrition, considering the broader sustainability framework, to ensure the health of our equine partners and the well-being of our environment in this rapidly changing world [2].

Horses, like other animals, obtain nitrogen (N) from the protein present in the feed they consume. In the equine sector, nitrogen is the feed consumption by-product that has the largest potential for negative environmental impact. The surplus protein in a horse's diet is eliminated as nitrogen (N) through perspiration, fecal matter, and urination [4]. Typically, nitrogen is efficiently utilized by plants, but in situations of high animal density, insufficient manure collection from pastures, and the resulting irregularities, the quality of vegetation and its capacity to effectively handle nitrogen are compromised. This situation can lead to nitrogen losses into ground and surface waters, causing water pollution [13] and greenhouse gas emissions [5]. Precision feeding, which entails precisely meeting the nutrient requirements of animals without exceeding them, offers a viable means of curbing nitrogen inputs [6]. Unfortunately, this approach is not widely adopted, given the prevalent practice of overfeeding protein within the equine industry, with some studies reporting horse owners providing as much as 150 %-161 % of the recommended crude protein requirements [7,8].

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The environmental impact of trace minerals like zinc (Zn), copper (Cu), manganese (Mn), and cobalt (Co) in horses' diets is a potential concern. These minerals are essential for equine health but excessive intake of these minerals can lead to their accumulation in horse manure, which, when not adequately managed, can increase the leaching potential of these minerals into the environment, affecting soil and water quality [9]. Inadequate waste management can exacerbate the adverse environmental consequences of this accumulation [10]. At an individual horse level the environmental impact may be limited but the size and intensive management systems associated with the ~450,000 horses in the Netherlands does have the potential for negative environmental impact given that each horse produces around 7 tons of phosphate and nitrogen rich manure per year [11], which for the industry represents approximately 3,150,000 tons annually.

At an individual farm level there appears to be little consideration of how the equine industry may contribute to nutrient leaching, with most small horse stable keeper's primary interest in horse manure utilization being focused on improving land use, rather than minimizing the environmental footprint [12]. This focus may reflect that despite the Dutch National Institute for Public Health and the Environment, identifying that the amount of copper and zinc leaching from agricultural soils is the most difficult in the Netherlands to reduce [14,15], at a regulatory level the Regulation (EU) 2018/848 on organic production of agricultural products does not currently contain any limitations for the copper and zinc content of horse manure [16], thus providing little incentive for horse keepers to consider these points.

Sustainable management practices and a greater understanding of the environmental impacts of these minerals within the equine diet are essential to reduce their negative effects on ecosystems and promote responsible horse ownership. Eastern and Western Europe together house more than 6.5 million equines used in agriculture and sport, leading to the risk of accumulation of horse manure in concentrated areas [17]. Although limited research has been conducted to comprehensively understand the environmental impact of equine feeding practices, preliminary findings suggest a substantial influence. Cross sectional surveys provide a mechanism to initially estimate the potential scale of the environmental impact of horse feeding practices. Thus, the objective of this study was to use data collected via a cross sectional survey to describe current equine feeding practices in the Netherlands and identify aspects of these that could be associated nutrient leaching and potential environmental contamination.

2. Material and methods

This study used a combination of data collected from an online survey and detailed nutritional analysis of a small cohort of representative horses. The target population were horse and yard owners located in the Netherlands with horses aged 4 to 14 years old that the participants considered to be in generally good health and with good body condition.

2.1. Survey

An online survey was designed to evaluate sustainable horse feeding and management practices in the Netherlands. Pre-testing via a pilot survey was conducted and resulted in one iteration of edits to improve question structure and clarity of questions. Legal and ethical considerations meant information provided remained anonymous including the option for participants to be removed from study at any time by request. A copy of the survey can be obtained from the corresponding author.

The survey was distributed online by the KNHS ('Koninklijke Nederlandse Hippische Sportfederatie' - 'Royal Dutch Equestrian Federation') and Pavo (a large Dutch feed company) March to June 2022. The survey utilized a combination of free text, option and ranking questions to collect information. Data were collected on the yard type, yard size (number of horses) and geographical location, demographic information about the horses were collected that included their age, sex, breed, and body weight. For each nominated horse the daily level of activity, as well as data about their dietary intake including grazing system, grazing duration, pasture area size, forage intake, supplementary feed, supplements, and the quantities provided were collected.

2.2. Ration calculation

Each horse's diet was analyzed in relation to their estimated daily nutritional intakes for the total diet (forage, concentrates and supplements) and requirements. The nutrient intake for energy, starch, sugar, crude fat, crude protein, lysine, copper, manganese, zinc, and cobalt were calculated, an estimate of workload was also calculated, and these data were used to compare the estimated intake with the estimated horse requirements using NRC recommendations [18]. The predicted nutrient composition of the pasture and forage offered were estimated based on the published NRC values [18], while the data for feed and supplements was based on publicly available product data. Pasture DM intake was estimated at 1.2 g DM/kg$^{0.75}$ for a 500 kg horse [18]. The pasture DM intake was estimated for the initial 4h at pasture as 1.5 g DM / kg BW / h and for every hour after the initial 4 hours as 0.9 g DM / kg BW / h based on published estimated intakes [19].

The ME requirement for horses between 200 and 800 kg was calculated according to Kienzle and Zeyner [20]. The energy requirement calculation included an adjustment for activity level. The owners chose the workload categories listed by assigning the ME increments above maintenance (20 %, 40 %, 60 %, and 90 %) to the arbitrary classifications "light," "moderate," "heavy," and "very heavy" [18]. The provision of nutrients for energy, crude protein, lysine, copper, manganese, zinc, and cobalt were classified as low (<90 %), normal (90 %–110 %), and high (>110) of the requirement compared to the NRC recommendations [18].

The potential mineral excretion for copper, manganese, zinc, and cobalt was estimated by subtracting the intake value from the requirement of horses. Any estimated excess CP intake was assumed to be excreted as Nitrogen (N) in the manure (feces and urine). Crude protein was converted to N using a conversion factor of 6.25 g protein per g nitrogen [18]. The wet weight of manure produced was assumed to be 5 % BW/day [21]. The mean value of excesses per day were translated into annual and then population level statistics.

2.3. Statistical analyses

Data were initially examined using descriptive statistic and plots. Normal distribution and homogeneity of the data were evaluated by Kolmogorov Smirnov and Levene tests, respectively. Normally distributed data are presented as mean ± standard deviation *(SD),* whereas skewed data are presented as median and range. Descriptive statistics were performed on the quantitative data describing percentage responses with 95 % confidence intervals. Chi-squared and k independent samples (Kruskal-Wallis) tests were used to explore whether the relationships between variables were statistically significant. Data were examined using SPSS 16.0 (IBM SPSS Statistics 28, Chicago, IL) and a value of $P < 0.05$ was considered statistically significant for all analyses.

3. Results

3.1. Demographics

There were 274 completed responses that provided data suitable for the analysis of the diet of horses. The median age of the horses was 8 (range 4 to 14 years), the majority of the horses were geldings (51 %), followed by mares (41 %) and stallions (9 %). The most common breed was warmblood horses (73 %), followed by cold blood horses (19 %) and ponies (8 %). The mean BW for warmbloods was 568.9 ± 62.9 kg, 578.5 ± 96.9 kg for coldbloods and 257.6 ± 56.7 kg for the ponies, with an overall sample mean BW of 542.4 ± 101.9 kg. The majority of horses were from livery yards (68.3 %), sport horse yards (20.2 %), riding school (10.4 %), and breeding yards (1.2 %).

3.2. Forage and Concentrates

The majority of the horses (85 %) had access to pasture, with a median grazing time of 10 hours per day (range 1 to 24 hours). A small proportion, approximately 4.4 %, had no turnout, while 10.6 % were turned out in sand paddocks. Pasture area per horse varied across the population offering grass pasture access. Just under half the population (45 %) provided pasture area of <50m^2 per horse, 15 % offered 51-99 m^2 per horse, 12 % between 100-199m^2 per horse and 28 % offered ≥200m^2 per horse. It was not possible for respondents to provide metrics of pasture mass or sward height. Considering pasture quality, 22 % of respondents said the grass cover was plentiful/lush, 69 % said medium, and 9 % identified it as bad/poor. Approximately half the respondents (48 %) stated they implemented rotational grazing (periodic alternation between pastures), 25 % used strip grazing (utilizing a moveable electric to allot access to regulated forage intake), 23 % provided continuous grazing (pasture access unrestricted over a long period of time) and 4.4 % grazed their horses on pasture also grazed by cattle.

Grass (meadow) hay (77 %) was the most common conserved forage offered to horses, followed by alfalfa (43 %) and grass haylage (35 %). Often combinations of conserved forage were offered, 13 % of the horses were fed both haylage and hay, and 27 % of the horses were fed alfalfa with another type of forage (either hay or haylage). Alfalfa hay was never offered as the only conserved forage, and only 10 % of horses were fed haylage as a sole forage source.

Only 16 horses (6 %) were not offered any concentrate feed and were only fed forage. Most of the horses (94 %) were provided concentrate feeds, with 46 % being fed two or more types. The median number of concentrates fed was 1 (range 1 to 4). Few of the horses (14 %, $n = 37$) were feed a diet that contained unprocessed grain. The most common unprocessed grains offered in descending order were soybean meal ($n = 10$), oats ($n = 9$), barley ($n = 6$), rice bran ($n = 2$) and one each for maize, and combinations of barley and soybean meal, barley and wheat bran, and oats and soy bean meal. The estimated quantities of forages and concentrates offered are provided in Table 1.

3.3. Supplements

The majority of the horses 80 % ($n = 219$) were offered more than 1 supplements, irrespective of the management strategy, with a median of two (range, 1–4) supplements offed per horse (Table 2) . The most commonly used supplements were multivitamins, muscle supports, chondro-protectives and gastrointestinal protectives. Herbal supplements were also used.

3.4. Nutrient analyses

Using the estimated quantities from the concentrates and forages offered and estimated pasture consumption the majority of the horses (90 %) were offered ME in excess of their predicted daily requirement, with a mean energy intake of 169.2 ± 61.1 MJ ME/d. Only 4 % of horses were estimated to be offered less than their recommended energy levels. The estimated CP intake of most of the horses (97 %) was greater than 110 % of the NRC recommendations, while 1 % of the horses had an estimated CP intake of below 90 % of the NRC recommendations. The average daily intake of CP was approximately 2.5 times the typical CP requirement of 924.9 ± 221.8 grams per horse per day. The mean CP intake (including pasture), was 4±2 g/kg BW. The mean complementary feed intake (as fed) per day was significantly higher in horses receiving more than 110 % CP (3.5±2.0 kg fed/d) than horses receiving recommended CP levels (1.6±1.2 kg as fed/d) ($P<0.001$). In terms of specific amino acids, the mean lysine intake at 43.4 ± 20.9 g was greater than the suggested NRC requirement of 36.2 ± 8.7 g per horse per day. The large standard deviation reflects the variation in the population regarding lysine intake with 55 % of the horses above 110 % of the NRC recommendations, and 24 % with an estimated lysine intake below the NRC recommendations.

Mean crude fiber intake was 6.5 ± 2.7 g/kg BW, and crude fat intake was 0.9 ± 0.5 g/kg BW, both being within NRC recommendations. However, average starch intake was 2.4 ± 0.8 g/kg BW, and sugar intake was 1.4 ± 1.2 g/kg BW, both of which were high compared to the recommendations [22].

The comparison of dietary intake of selected microminerals with the recommendations provided by NRC (NRC 2007) are presented in Table 3. Most of the minerals quantified were offered in excess of recommended daily requirements.

Table 1
The mean amount of forages consumed as fed basis with horses (kg/day) ($n = 274$).

Feeds	All horses intake (Mean ± SD)
Hay	8.4 ±5.0
Haylage	5.0 ± 4.9
Alfalfa	3.1 ± 4.7
Total forage intake	6.5 ± 5.9
Total concentrate intake	3.4 ± 2.0

Abbreviation: SD, standard deviation

Table 2
Feed intakes and combination with supplements ($n = 274$).

Concentrate	Horses n (%)	Supplement Use n (%)	One supplement use n (%)	More than 2 supplements n (%)
Only forage	16 (5.8 %)	13 (81.2 %)	2 (15.4 %)	11 (84.6 %)
Only grain	6 (2.1 %)	6 (100 %)	1 (16.7 %)	5 (83.3 %)
Only Commercial feed	209 (76.3 %)	169 (80.9 %)	37 (21.9 %)	132 (78.1 %)
Grain and Commercial feed	43 (15.7 %)	31 (72.1 %)	8 (25.8 %)	23 (74.2 %)

Table 3
The microminerals including Cu, Mn, Zn and Co intake n (% of horses) compared to NRC recommendations ($n = 274$).

Micro-mineral intake	Requirement horse/day (mg) (Mean ± SD)	Total Intake horse/day (mg) (Mean ± SD)	Low n (%)	Normal n (%)	High n (%)
Copper(Cu)	156.4 ± 33.7	234.1 ± 156.9	79 (28.8 %)	32 (11.7 %)	163 (59.5 %)
Manganese (Mn)	625.6 ± 134.6	1570.6 ± 595.2	2 (0.7 %)	1 (0.4 %)	271 (98.9 %)
Zinc (Zn)	625.6 ± 134.6	1044.6 ± 569.9	47 (17.2 %)	29 (10.6 %)	198 (72.3 %)
Cobalt (Co)	0.8 ± 0.2	2.9 ± 3.5	19 (6.9 %)	20 (7.3 %)	235 (85.8 %)

Low 0 %-90 %, normal 90 %-110 %, high >110 % of the requirement compared to NRC recommendations.

3.5. Potential excretion of Nitrogen and microminerals

Using the mean body weight of 542.4 ± 101.9 kg the average horse would produce approximately 27±5 kg (wet weight) of manure per horse per day. The estimated potential nitrogen excretion per horse per day was 228 ± 134 g, which equated to 8.47 kg N per ton manure (ref. value 5 kg N per ton) [21]. The estimated daily fecal excretion rates of microminerals would be approximately as follows: Copper (Cu) 141.0 ± 151.3 mg per day, Zinc (Zn) 593.1 ± 504.4 mg per day, Manganese (Mn) 957 ± 541.2 mg per day, and Cobalt (Co) at 2.3 ± 3.5 mg per day per horse.

4. Discussion

The cross section of the Dutch equestrian population that contributed data to this survey had a distribution across horse types and management systems that reflected previous estimates of the equestrian population. Thus, the data presented should provide a good reflection of the pattern of feeding and management within the Netherlands and potentially in other countries with semi-intensive management of sport and leisure horses. Data were obtained via an online survey and thus represents point estimates with the inherent variation expected with owner assessment of feed quantitates. The online survey provided the opportunity to access a wide cross section of the equestrian community, but this technique does prevent precise quantification or identification of the pasture species within the pasture and the meadow hay offered. To avoid introduction of additional bias and variation the published NRC variables were used to estimate the nutrient composition of the pasture and the conserved forage offered.

A consistent theme within the data was the offering of feedstuffs, and crude protein and minerals specifically, in excess of the published NRC requirements. The pattern of feeding appeared to be the provision of the majority of the horse's requirements (or all of the horses requirements) from the provision of conserved forages and concentrates. The pasture offered appeared to provide a "top up" rather than be considered as a primary feed source. This approach is not uncommon within the equine sector and may reflect the difficulty for horse managers to estimate pasture intake and the restricted space for horse keeping [26].

The majority of horses were provided access to pasture with a management system that reflected the horses were out at pasture during the day and in a stable or loose box during the night. However, further examination of the data indicates that for half of these horses the pasture turnout was heavily restricted with 45 % of the horses having a daily pasture allocation of $\leq$50m^2 (equivalent to an area 5m by 10m). A pasture allocation of $\geq$ 200m^2 per horse, was reported to be optimal for environmental sustainability and welfare-friendly horse husbandry [23]. Given the limited space and pasture quality, the horses' actual pasture intake may vary. Time budget data demonstrates that the majority of the horse's daily activity is centered around grazing and movement between grazing locations. Thus, management systems that permit sustained movement and grazing reflect the horse's evolutionary ecological niche. However, adequate or ideal pasture allocation may not be possible in a small country such as the Netherlands with a relatively high horse population. Provision of pasture space less than 200m^2 per horse could lead to increased areas with bare and compressed soil [11]. Limited pasture turnout space, or inability to provide a rotation of pasture to permit grasses and legumes to achieve a vegetative or reproductive stage can lead also to overgrazing, erosion and the inability of the pasture species in these areas to effectively utilize nutrients that are excreted in horses' feces and urine.

Most horses in Netherlands are kept for sport and leisure and this may explain the greater proportion of the diet that was provided as conserved forages 6.5 (3.1 - 8.4) kg / horse / day) when the results of this survey are compared to data from originating from racing populations (4.7 kg / horse / day, 3.3 kg / horse / day and 4.82±0.2 kg / horse / day for Turkey [24], Australia and New Zealand respectively) [25] or even sport horses in other countries such as New Zealand 3.9 (2.0-5.8) kg/ horse/ day) [26]. The forage intake within the surveyed group equates to approximately 1.1 % of the horse's body weight on a dry matter basis, thereby satisfying the minimum requirement set by the NRC [18]. However, it falls short of the recommended intake level, which is a minimum of 1.5 % of the horse's body weight. It is important to note that this lower intake level has the potential to negatively affect gastrointestinal health [27]. Furthermore, it may lead to an increased reliance on concentrate feeds, necessitating further processing and, consequently, undermining sustainability efforts.

The level of concentrates offered (mean 3.4 kg) was approximately half that offered racehorses but was greater than that offered sport horses in New Zealand (1.7kgs (1.0-2.8) kg which may reflect the greater proportion of the diet originating from pasture in the New Zealand management system. The limited offering of pasture as a feed source within the Dutch equestrian sector simplifies the quantification of feed supply, feed demand and any excess nutrients and minerals. The mixing of different "complete" formulated concentrate feeds and the addition of supplements could lead to dietary inconsistency, potentially resulting in over-supplementation of certain minerals and inadequate supplementation of others. This mixing of complete feeds and the addition of multiple supplements is a common trend across surveys on horse feeding [3,26]. This mixing may explain the elevated estimates of the minerals copper (Cu), cobalt (Co), manganese (Mn), and zinc (Zn) in the diets examined. Many trainers and horse owners may lack a comprehensive understanding of their horses' mineral and vitamin requirements, as well as the nutritional content provided by commercial feeds and supplements. Consequently, selecting the appropriate supplements becomes a challenging task.

The quantity of feed offered provided diets with excess energy, in some cases up to 57 % above NRC requirements. Despite providing diets with a large proportion of conserved forage the starch intake (mean 2.4 g/kg BW) was higher than the NRC guidelines. While neither the energy or starch content *per see* provide a significant issue in relation to excretion of protein and minerals, the provision of excess can lead to associated health and management issues. In contrast excess protein offered in the diet, that cannot be utilized, will be excreted in feces and urine, providing a potential for nitrogen leaching. Excess crude protein appears to be common trend in equine diets with a number of reports of diets containing up to 161 % of the CP requirements [8,28]. However, it is necessary to accurately meet protein needs and consider protein quality [29]. The excessive feeding could be attributed to horse owners having difficulty distinguishing between the nutritional needs of maintenance horses and those in active work. It was observed that maintenance horses tended to be overfed more compared to their working counterparts [8]. Maintenance horses require fewer nutrients according to the NRC guidelines; however, they often receive the same type and concentrate feed as working horses, albeit in smaller quantities. Typically, maintenance horses can thrive on diets composed solely of forage [4] and the offering of concentrates as observed here and in other studies [28] indicates that horse owners tend to offer concentrate feeds even when they are not necessary. Thus, for some horse owners the motivation to offer concentrates may not be driven by perceived feed demand as opposed to not wanting the horse to "miss out" on what they perceive to be desirable aspect of the diet.

Data from the current study indicates that the average horse in the Netherlands will have an estimated nitrogen excretion per horse per day of 228 g, which similar to other published values for horses [28]. These values are less than those reported for similar size ruminants such as a beef cow 296g N daily or dairy cow 530g per day [30]. Although N excretion per unit animal is less for the horse than beef or dairy cows, based on current population numbers (~450,000 horses) the Dutch equine industry may be producing 37.4 metric tons of N per annum. Reducing the CP offered within the feed may reduce this value, however, management of waste (urine, feces and bedding) has the largest impact on the potential for nitrogen leaching and environment consequences.

Managing nitrogen outputs in equine operations relies heavily on insights drawn from other livestock facilities, complemented by a limited number of initial projects carried out on horse farms [6].

Nitrogen in the feces and urine must be managed to prevent consequences to the environment, such as contamination of water and the deterioration of air quality [31]. The common management system of at pasture (turn out) during the day and in stables or loose boxes at night for most of the horses surveyed identifies there are two primary aspects to consider; can the pasture capture and utilize the nutrients excreted nutrients in feces and urine and what is the best strategy to manage soiled bedding to reduce leaching risk? Nitrogen leaching potential is heavily dependent on the soil type and the pasture growth to utilize the free nitrogen. The data obtained on pasture allocation indicates limited pasture mass and area, in which case reduction in excess dietary protein would provide the most efficient mechanism to mitigate the potential for nitrogen leaching [32]. Appropriate fermentation and degradation of used bedding (bedding, feces and urine) and within areas that minimize leaching (covered and with a nonporous base) reduces the generation of methane gas and permits the resultant product to be used as an organic fertilizer.

The excessive excretion of minerals from horses through their manure raises concerns about mineral leaching. When the surplus exceeds the plants' (pasture) capacity to absorb these minerals, they can accumulate in the soil or leach into nearby water systems. Of concern are trace elements like cobalt, copper, manganese, and zinc, which, in substantial quantities, can be harmful to plants, microorganisms, and aquatic organisms [9]. Excess minerals offered in the diet are subsequently identified in elevated levels within the horse manure [10]. The limited pasture turnout space may inadvertently provide a mechanism for localized increases in these.

5. Conclusions

This study described the prevalent feeding practices among horses in the Netherlands, revealing a large portion of the population had access to limited pasture areas. Grass (meadow) hay was the primary conserved forage offered, while concentrate feeds, in moderate quantities were supplied to the majority of horses with provision of multiple types of dietary supplements. The data indicates that a significant proportion of horses are potentially overfed, leading to elevated energy, carbohydrate and protein intake. Excess protein offered is excreted as nitrogen and has the greatest potential environmental consequences Annually, these horses may generate up to 8.47 kg of nitrogen per ton of manure. Mitigation of the risk of N leaching could be achieved by moderation of the crude protein offered in the diet and development of manure management strategies. The excess minerals offered in the diet may provide another negative environmental consequence given the high density of horses in the Netherlands and the opportunity for concentrated areas of excretion given the limited pasture area allocated to most horses. This study underscores the critical link between dietary choices, nutrient intake, and the potential environmental effects, and emphasizes the need for horse owners in the Netherlands to take proactive steps to achieve a more balanced and sustainable diet for their equine companions.

Ethical Statement

There are no human/animal subjects in the article and informed consent is not applicable.

CRediT authorship contribution statement

Gulsah Kaya Karasu: Writing – original draft, Resources, Methodology, Funding acquisition, Data curation. **Chris W Rogers:** Writing – review & editing, Supervision.

Declaration of competing interest

The authors whose names are listed immediately below certify that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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