# A preliminary investigation into the mineral intake of horses in the UK

Katie Grimwood[a], Lee-Ann Penaluna[b] and Dr Hieke Brown[b*]

[a] Department of Biolotical and Medical Sciences, Oxford Brookes University, Headington Campus, Oxford, United Kingdom

[b] Department of Land-based Industries and Life Sciences, Abingdon and Witney College, Abingdon, United Kingdom

[*] Corresponding author: Dr Hieke Brown, Hartpury College, Hartpury, Gloucestershire, GL19 3BW, UK. Email address: Hieke.Brown@hartpury.ac.uk

Submitted to Journal of Equine Veterinary Science: 29 September 2015

**Abstract**

The diet of the domesticated horse is influenced by both internal and external variables, such as age, breed, discipline, and workload, as well as the feed brand preference of the owner. With a range of products and feeds available to the horse owner, this has the potential to lead to inappropriate feeding management. The aim of this study was to evaluate the current mineral intakes of horses in the UK. An online questionnaire was used to collect data on horse and owner demographics and feed rations. Total daily intakes of phosphorus, calcium, sodium, and potassium were calculated based on forage, concentrate and supplement information given in the questionnaire. Estimated mineral intakes were compared to recommended levels using a Wilcoxon Signed Rank test. Intakes of phosphorus, calcium, sodium and potassium were found to be significantly ($P<0.001$) higher than NRC recommendations, with the majority of the estimated mineral intakes originating from the forage component of the diet. However, the calcium to phosphorus ratio was calculated at 2.07:1, which is close to the recommended ratio limits. Excess intakes of calcium, phosphorus, sodium and potassium have the potential to influence the metabolism of additional macro and micro minerals and therefore further research into this area is recommended.

**Keywords:** equine; nutrition; mineral; feeding

## 1.0 Introduction

Knowledge within the field of equine nutrition has been increasing over recent years, specifically focussing on the importance of producing appropriate rations to ensure health and welfare of the horse. The diet of the domesticated horse is influenced by various internal and external factors, including age, breed, discipline and environment [1,2]. As a result, it can be a challenge for many horse owners to provide their horses with a correct and balanced diet. With a range of products and feeds available to the horse owner, this has the potential to lead to inappropriate feeding management, which may result in health problems such as laminitis, obesity, and exertional rhabdomyolysis [3,4].

Recent surveys investigating feeding practices of general horse owners identified that owners base their feeding regimes on information received from various sources, including veterinarians, trainers, magazines and books and the internet [5-7]. Further results also identified that the majority of owners fed a diet consisting of forage and premixed concentrate feed with the inclusion of at least one supplement [5, 7, 8]. The number of supplements may indeed increase depending on the performance level of the horse, as Burk and Williams [9] reported that horses competing at CCI** and CCI*** received an average of 4.2 supplements per day. Although joint supplements were the most common supplement provided to these horses, 92% of riders surveyed by Burk and Williams [9] also provided their horses with additional electrolytes on a daily basis, compared to 38% of leisure horses, including those in light work [5].

As it has been reported that owners are unlikely to seek advice on supplement requirement or efficacy [7], there is potential for supplementation to lead to excess mineral intakes [10]. The aim of this study was therefore to investigate current feeding management of horses in the UK, with specific regard to mineral intakes. It was specifically hypothesised that mineral intakes would be significantly different from guidelines provided by the National Research Council [11].

## 2.0 Materials and methods

An online survey was created and published through social media websites and equestrian interest groups with the aim of targeting horse owners in the UK. Generic questions aimed to compile demographic information of the owner (e.g. gender, age, and region), as well as the

number of horses owned. If more than one horse was owned, participants were asked to select one horse for the completion of the questionnaire. Alongside basic details of the horse including breed, age, weight, and workload, questions focussed on feeding management and practices, including grass turnout, roughage and concentrate feed and the use of supplements.

Based on the information received, estimations were made on grass intake during turnout and voluntary dry matter intake (VDMI) based on recommendations in the NRC guidelines [11]. VDMI was calculated for each horse assuming an average intake of 2% bodyweight (BW) [11]. This was further divided by 24 to obtain values for approximate intakes per hour (kg / hr). Grass intake was estimated using the median value for number of hours turned out to grass. Total weight of conserved forages received by each horse per day was stated in the questionnaire responses.

Following data collection, approximate daily intakes of phosphorus (P), calcium (Ca), sodium (Na) and potassium (K) were calculated for each horse, based on the nutrient compositions provided by the manufacturers of concentrate feeds and supplements given in the questionnaire responses. Standard values for forage mineral content were based on forage analysis reports provided by Baileys Horse Feeds (Table 1). Intake recommendations for each mineral were calculated for each horse based on estimated workload and BW, using the NRC online computer programme [11].

**Table 1. Mineral contents of forage** (adapted from forage analysis values provided by Baileys Horse Feeds, 2015). Values are expressed as a percentage of DM intakes

| Mineral | Grass | Hay | Haylage | Both Hay and Haylage received* |
|---|---|---|---|---|
| % Dry Matter | 25 | 84 | 56.5 | 70.25 |
| Phosphorus | 0.40 | 0.30 | 0.21 | 0.25 |
| Calcium | 0.85 | 0.65 | 0.33 | 0.49 |
| Sodium | 0.31 | 0.35 | 0.31 | 0.33 |
| Potassium | 3.00 | 2.25 | 2.25 | 2.25 |

* Mean values of hay and haylage used to estimate mineral intake for horses receiving both forage types

### *2.1 Data analysis*

A Shapiro-Wilks test for normality was performed on the data. As all samples showed a significant deviation from the normal distribution, non-parametric analysis was performed on the data. A related samples Wilcoxon Signed Rank Test was used to determine any differences between estimated nutrient intake and recommended nutrient intakes. Horses were further grouped according to their estimated workload, ranging from maintenance to very heavy workload. A one-way ANOVA was performed to determine whether the average BW of horses was significantly different between workload groups. In addition, an independent samples Kruskal-Wallis test was performed to compare estimated nutrient intake between different workload groups. For all tests, the level of significance was set at $P = 0.05$.

## 3.0 Results

A total of 218 responses were received, which represented a range of breeds, including Thoroughbreds (25%), Welsh ponies (8%) and Irish Sports Horses (8%). On average, horses weighed 531.9 ± 121.3 kg (range: 100 – 800 kg), with the majority of owners determining the horse's BW using a weigh tape (42%) or visual estimation (31%). However, 8% (n=18) of respondents did not provide a weight for their horse. The majority of horses (65%) were assigned a 'moderate' fat score of three on a scale of 0 - 5, although 20% of horses were classed as 'overweight' or 'obese'. Respondents were active in a wide range of equestrian disciplines or activities, with hacking (27%), dressage (13%) and general purpose (9%) being the most common responses. A range of workloads were recorded, ranging from maintenance (14%) and light work (18%) to intense work (4%), with the majority of respondents rating their horse's workload as moderate (45%).

Of the respondents, 97% of horses received fresh grass and 72% of horses received some form of roughage, with the most common type being hay (56%). Fourteen percent of owners had their forage analysed in the last 12 months, although these results were not provided for this investigation. In addition to the forage, 82% of horses received concentrate feed and 67% received additional feed supplementation. The median number of supplements per horse was two (range 1 – 8 supplements). The most common use of a feed supplement was for joint health (19%), but fly repellent (e.g. garlic), digestive health and overall health were also given as important reasons (11%, 9% and 8%, respectively).

Of the 218 responses received, 36 responses were removed from the study prior to mineral intake analysis due to insufficient supply of data on dietary intakes, leaving 182 suitable responses (83%). The estimated intakes for phosphorus, calcium, potassium and sodium within the total diet were significantly ($P<0.001$) greater than levels recommended by the NRC [11] (Figure 1). The main source for minerals was through forage (Figure 2). Although the estimated intake was significantly ($P<0.001$) greater than recommended, it was found that the calcium to phosphorus ratio ranged from 1.44:1 to 2.58:1. However, on average the ratio of intakes was 2.07:1.

After grouping the horses according to their workload, it was established that the average BW of horses differed significantly ($P<0.05$) between different workload groups. Similarly, recommended mineral intakes were significantly different between horses of a different workload. However, when comparing the mineral intakes between horses undertaking different levels of work, only the estimated intakes for calcium and sodium were found to be significantly ($P<0.05$) different (Figure 3). Where estimated intakes for calcium showed a decrease as workload increased, estimated sodium intakes did not show any particular pattern.

## 4.0 Discussion

The estimated intakes for minerals were significantly ($P<0.001$) higher compared to recommended intakes [11]. Compared to previous reported intakes [10], phosphorus and calcium intakes were slightly lower. Excess phosphorus intakes are of particular concern with lower calcium intakes, reported to result in the development of nutritional secondary hyperparathyroidism [12-14]. Although both calcium and phosphorus were fed in excess, the ratio at which this was provided was found to be appropriate, although towards the higher end and in slight excess of the recommended ratio of 2:1 [11]. High calcium intakes could be beneficial during muscle recovery following exercise through its role as a biological messenger [15], making this particular of interest as the majority of horses in the current study were considered to be in moderate work or higher. However, excess calcium has also been reported to have a negative effect on magnesium concentrations, particularly before exercise and 24 hours after exercise [15]. As magnesium plays an important role in cellular respiration, nerve conduction, and bone and mineral homeostasis [16], excess intakes of calcium and phosphorus should be avoided. However, further research will be required to confirm the full

effects on magnesium metabolism. Within the current study no health problems relating to reduced magnesium absorption were reported, suggesting that any negative effects of the excess intake of calcium and phosphorus may be limited.

Potassium intake was estimated to be 7.7x in excess of recommended intakes, which was considerably higher than previous reports [10, 17]. Although hyperkalaemia has been reported to result in neuromuscular hyper-excitability and cardiac arrhythmia in intensely exercised horses [10, 18], increased excretion via urine may also be expected with a limited increase of faecal potassium levels to allow for maintenance of potassium homeostasis within the body [17]. In addition, excess sodium levels have been reported to result in increased sodium levels in faeces [19] and in urine [20]. With the majority of mineral excesses being removed via the urinary tract, this may have the potential to lead to kidney failure due to increased filtration rates placing strain on the kidneys. A limitation of the questionnaire from this study was that no estimations were provided regarding the water intake of the horses. As a result, it was not possible to determine a relationship between excess mineral intakes and water requirements.

As can be seen in figure 2, the majority of mineral intake originated from forage. It is acknowledged that these estimated mineral intakes may be the result of over estimation, as the estimated intakes and recommended intakes were based on factors including VDMI, BW and workload amongst other. VDMI intakes were estimated at 2% BW per horse, even though a range of 1.5% - 3% BW has been reported [21, 22]. In addition, owners were asked to provide BW and workload levels for their horse. Although guidance was provided alongside the questions, previous studies have reported inaccuracies of BW measurements using visual estimations or weigh tapes [23] as well as estimation of workload [24].

Forage mineral levels were determined using forage analysis values provided by Baileys Horse Feeds. These values may be considered to be representative, although variation between geographical locations within the UK should be considered. In addition, mineral contents are likely to have been over-estimated for soaked hay, as no standardised nutritional values were available. Soaking of hay can decrease potassium content by 30 – 40%, phosphorus by 52% and sodium by 43% [25]. Therefore these results should be considered as preliminary estimations only.

When comparing mineral intakes between horses with different perceived workloads, only sodium and calcium were found to differ significantly ($P<0.05$) between workload intensities. Interestingly, calcium levels demonstrated a decrease as workload increased. With calcium playing a vital role in maintaining bone health [26], this could potentially predispose the horses in heavier workloads to injuries and fractures. However horses across all levels of work intensities received minerals in excess of recommendations, suggesting that horses in higher workloads may be fed more efficiently by their owners. In contrast, potassium levels did not differ significantly ($P>0.05$) between the different work intensities. With the majority of potassium becoming available through forage, it can be assumed that all horses used within this study were receiving sufficient forage in their diets. A slight decrease in median potassium intake can be noted (Figure 3) as workload increases, which may reflect a slight reduction in the forage to concentrate ratio of horses in moderate to very heavy work.

## 5.0 Conclusion

This questionnaire-based study aimed to investigate the mineral intake of horses in the UK and to compare this with NRC guidelines. From the results it can be concluded that there are significant differences between estimated and recommended intakes of phosphorus, calcium, potassium and sodium received by horses in the UK. Forage was found to be the main contributor of estimated mineral intake. It was of interest to note that although all investigated minerals were fed in excess, the calcium to phosphorus ratio was concluded to be appropriate. Although no mineral-specific health problems were noted in the current study sample, these cannot be ruled out for the population as a whole, especially as excess intakes may impact on the absorption of additional macro and micro minerals, requiring further investigations into this area.

## Acknowledgements

The authors thank Dodson and Horrell Ltd. for their support with this study and the provision of a prize draw incentive for questionnaire participation. In addition, the authors thank Baileys Horse Feeds for providing forage analysis data.

## References


[1] Bamford NJ, Potter SJ, Harris PA, Bailey SR. Breed differences in insulin sensitivity and insulinaemic responses to oral glucose in horses and ponies of moderate body condition score. Dom Anim Endocrinol 2014; 47; 101-7

[2] Harris PA. Review of equine feeding and stable management practices in the UK concentrating on the last decade of the 20th century. Equine Vet J 1999; 31; 46-54

[3] Medina B, Girard ID, Jacotot E, Julliand V. Effect of a preparation of *Saccharomyces cerevisiae* on microbial profiles and fermentation patterns in the large intestine of horses fed on a high fibre or high starch diet. J Anim Sci 2002; 80; 2600-09

[4] Frank N, Geor RJ, Bailey SR, Durham AE, Johnson PJ. Equine metabolic syndrome. J Vet Intern Med 2010; 24; 467-75

[5] Hoffman CJ, Costa LR, Freeman LM. Survey of feeding practices, supplement use and knowledge of equine nutrition among a subpopulation of horse owners in New England. J Equine Vet Sci 2009; 29; 719-26

[6] Martin O. Feeding horses at the Winter Equestrian Festival: A review of common practices. In 17th Kentucky Equine Research nutrition conference: Feeding and Veterinary Management of the sport horse 2010. Lexington, Kentucky, USA 127-30: Kentucky Equine Research

[7] Murray JA, Bloxham C, Kulifay J, Stevenson A, Roberts J. Equine Nutrition: A survey of perceptions and practices of horse owners undertaking a massive open online course in equine nutrition. J Equine Vet Sci 2015; 35; 510-17

[8] Wylie CE, Ireland JI, Collins SN, Verheyen KLP, Newton JR. Demographics and management practices of horses and ponies in Great Britain: A cross-sectional study. Res Vet Sci 2013; 95; 410-17

[9] Burk AO, Williams CA. Feeding management practices and supplement use in top-level event horses. Comp Ex Phys 2008; 5, 85-93

[10] Williams CA, Parise BA, Burk AO. Elite three day event horses are over-supplemented during competition. J Anim Psych Anim Nutr 2009; 93; 146

[11] NRC. Nutrient Requirements of horses. 6th ed. Washington: National Academies Press; 2007

[12] Bas S, Bas A, López I, Estepa JC, Rodriguez M, Aguilera-Tejero E. Nutritionally secondary hyperparathyroidism in rabbits. Domest Anim Endocrinol 2005; 28; 380-90

[13] Krook L, Whalen JP. Nutritional secondary hyperparathyroidism in the animal kingdom: report of two cases. Clin Imag 2010; 34; 458-461

[14] Coenen M. Macro and trace elements in equine nutrition, in: Geor RJ, Harris PA, Coenen M, editors. Equine Applied and Clinical Nutrition, Edinburgh: Elsevier Ltd; 2013, p.190-228

[15] Vervuert I, Stanik K, Coenen M. Effects of different levels of calcium and phosphorus intake on calcium homeostasis in exercising horses. Eq Vet J 2006; 36; 659-663

[16] Stewart AJ. Magnesium disorders in horses. Vet. Clin. Equine 2011; 27; 149-163

[17] Jansson A, Lindholm A, Lindberg JE, Dahlborn K. Effects of potassium intake on potassium, sodium, and fluid balance in exercising horses. Eq. Vet. J. 1999; 30; 412-17

[18] Hess TM, Greiwe-Crandell KM, Waldron JE, Williams CA, Lopes MA, Gay LS, et al. Potassium-free electrolytes and calcium supplementation in an endurance race. Comp Ex Phys 2008; 5; 33-41

[19] Hoyt JK, Potter GD, Greene LW and Anderson JG. Mineral balance in resting and exercised miniature horses. J Eq Vet Sci 1995; 7; 310-314

[20] Schryver HF, Parker MT, Daniluk PD, Pagan KI, Williams J, Soderholm L and Hintz HF. Salt consumption and the effect of salt on mineral metabolism on horses. Cornell Vet 1987; 77; 122-131

[21] LaCasha PA, Brady HA, Allen VG, Richardson CR, Pond KR. Voluntary intake, digestibility, and subsequent selection of Matua bromegrass, coastal bermudagrass and alfalfa hays by yearling horses. J. Anim. Sci. 1999; 77; 2766-73

[22] Staniar EB, Bussard JR, Repard NM, Hall MH, Burk AO. Voluntary intake and digestibility of teff hay fed to horses. J. Anim. Sci. 2010; 88, 3296-3303

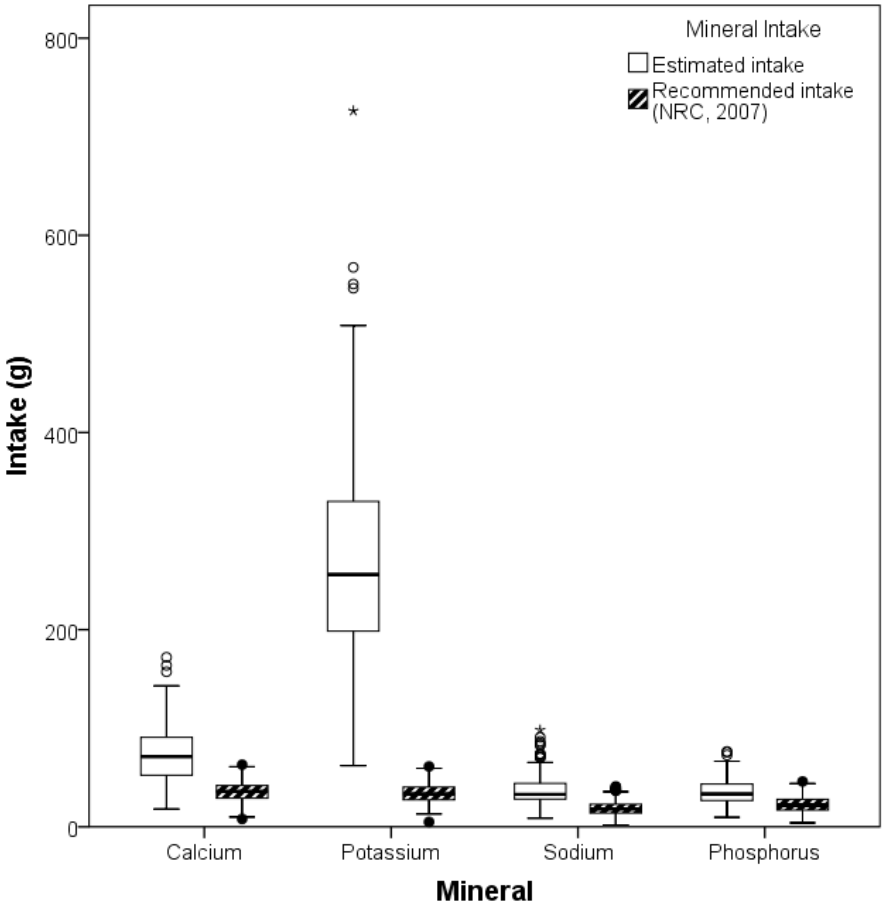
[23] Ellis JM, Hollands T. Accuracy of different methods of estimating the weight of horses. Vet. Rec. 1998; 143; 335-6

[24] Dekker H, Marlin D, Alexander L, Bishop R, Harris P. A pilot study investigating the relationship between perceived and actual workload and estimated energy intake in riding centre horses. Equine Comp Ex Phys 2007; 4; 7-14

[25] Blackman M, Moore-Coolyer MJS. Hay for horses: the effects of three different wetting treatments on dust and nutrient content. Anim. Sci. 1998; 66; 745-50

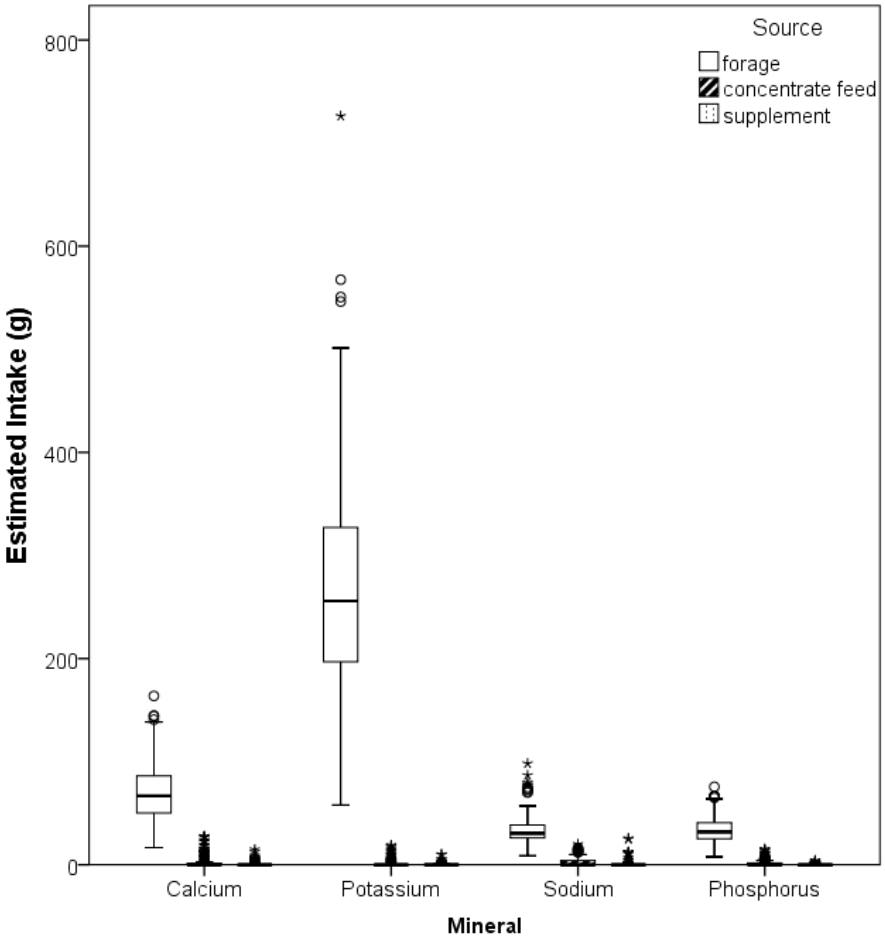
[26] Toribio RE. Disorders of calcium and phosphate metabolism in horses. Vet Clin N Am Eq Pract 2011; 27; 129-147

**Figure 1. Comparison of daily estimated intake and recommended intake of calcium, potassium, sodium and phosphorus.**



294 **Figure 2. Daily estimated intake of calcium, potassium, sodium and phosphorus per**
295 **feed source.**

296




297

298

299

**Figure 3. Comparison of daily estimated intake of calcium, potassium, sodium and phosphorus between horses with different levels of perceived workload.**