

## **A Preliminary Investigation Into the Mineral Intake of Horses in the UK**

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

2

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13 **Abstract**

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

29

30

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

32

33

## 34 **1.0 Introduction**

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

43

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

55

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

62

## 63 **2.0 Materials and methods**

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

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

72

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

80

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

88

89 **Table 1. Mineral contents of forage** (adapted from forage analysis values provided by  
90 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

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

93

94 2.1 Data analysis

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

104

105 **3.0 Results**

106 A total of 218 responses were received, which represented a range of breeds, including  
107 Thoroughbreds (25%), Welsh ponies (8%) and Irish Sports Horses (8%). On average, horses  
108 weighed  $531.9 \pm 121.3$  kg (range: 100 – 800 kg), with the majority of owners determining the  
109 horse's BW using a weigh tape (42%) or visual estimation (31%). However, 8% ( $n=18$ ) of  
110 respondents did not provide a weight for their horse. The majority of horses (65%) were  
111 assigned a 'moderate' fat score of three on a scale of 0 - 5, although 20% of horses were  
112 classed as 'overweight' or 'obese'. Respondents were active in a wide range of equestrian  
113 disciplines or activities, with hacking (27%), dressage (13%) and general purpose (9%) being  
114 the most common responses. A range of workloads were recorded, ranging from maintenance  
115 (14%) and light work (18%) to intense work (4%), with the majority of respondents rating their  
116 horse's workload as moderate (45%).

117

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

126

127 Of the 218 responses received, 36 responses were removed from the study prior to mineral  
128 intake analysis due to insufficient supply of data on dietary intakes, leaving 182 suitable  
129 responses (83%). The estimated intakes for phosphorus, calcium, potassium and sodium  
130 within the total diet were significantly ( $P<0.001$ ) greater than levels recommended by the NRC  
131 [11] (Figure 1). The main source for minerals was through forage (Figure 2). Although the  
132 estimated intake was significantly ( $P<0.001$ ) greater than recommended, it was found that the  
133 calcium to phosphorus ratio ranged from 1.44:1 to 2.58:1. However, on average the ratio of  
134 intakes was 2.07:1.

135

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

144

#### 145 **4.0 Discussion**

146 The estimated intakes for minerals were significantly ( $P<0.001$ ) higher compared to  
147 recommended intakes [11]. Compared to previous reported intakes [10], phosphorus and  
148 calcium intakes were slightly lower. Excess phosphorus intakes are of particular concern with  
149 lower calcium intakes, reported to result in the development of nutritional secondary  
150 hyperparathyroidism [12-14]. Although both calcium and phosphorus were fed in excess, the  
151 ratio at which this was provided was found to be appropriate, although towards the higher end  
152 and in slight excess of the recommended ratio of 2:1 [11]. High calcium intakes could be  
153 beneficial during muscle recovery following exercise through its role as a biological messenger  
154 [15], making this particular of interest as the majority of horses in the current study were  
155 considered to be in moderate work or higher. However, excess calcium has also been reported  
156 to have a negative effect on magnesium concentrations, particularly before exercise and 24  
157 hours after exercise [15]. As magnesium plays an important role in cellular respiration, nerve  
158 conduction, and bone and mineral homeostasis [16], excess intakes of calcium and  
159 phosphorus should be avoided. However, further research will be required to confirm the full

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

163

164 Potassium intake was estimated to be 7.7x in excess of recommended intakes, which was  
165 considerably higher than previous reports [10, 17]. Although hyperkalaemia has been reported  
166 to result in neuromuscular hyper-excitability and cardiac arrhythmia in intensely exercised  
167 horses [10, 18], increased excretion via urine may also be expected with a limited increase of  
168 faecal potassium levels to allow for maintenance of potassium homeostasis within the body  
169 [17]. In addition, excess sodium levels have been reported to result in increased sodium levels  
170 in faeces [19] and in urine [20]. With the majority of mineral excesses being removed via the  
171 urinary tract, this may have the potential to lead to kidney failure due to increased filtration  
172 rates placing strain on the kidneys. A limitation of the questionnaire from this study was that  
173 no estimations were provided regarding the water intake of the horses. As a result, it was not  
174 possible to determine a relationship between excess mineral intakes and water requirements.

175

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

184

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

192



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

205

## 206 **5.0 Conclusion**

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

217

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221 Horse Feeds for providing forage analysis data.

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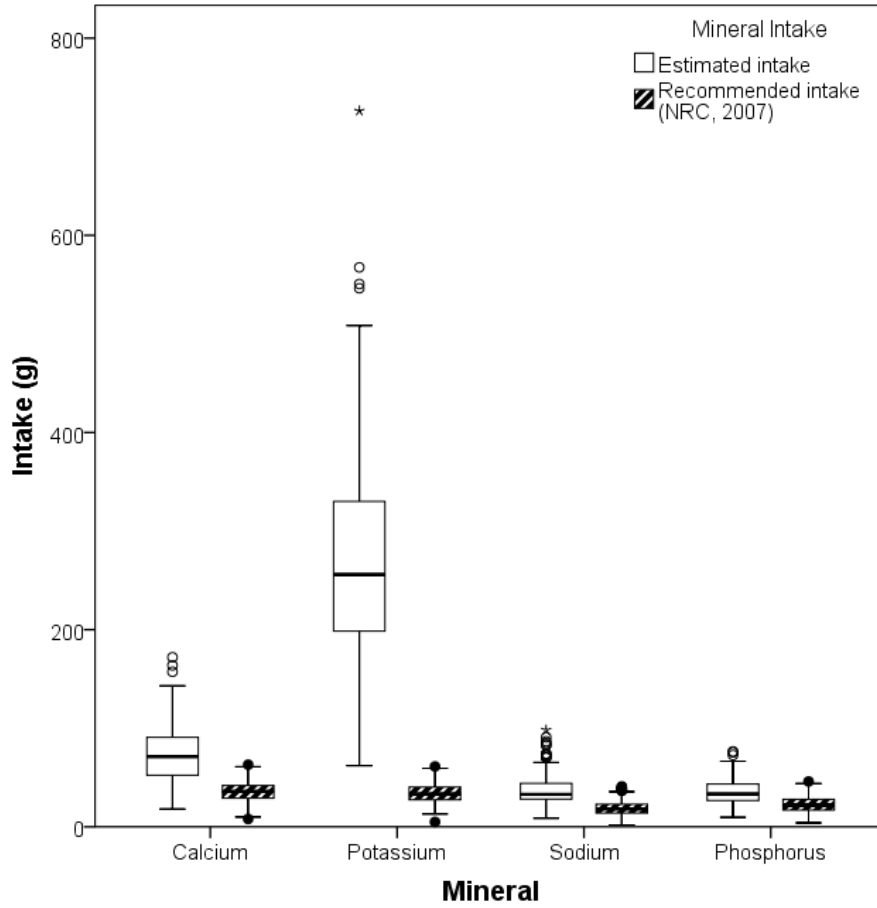
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287 **Figure 1. Comparison of daily estimated intake and recommended intake of calcium,**  
288 **potassium, sodium and phosphorus.**

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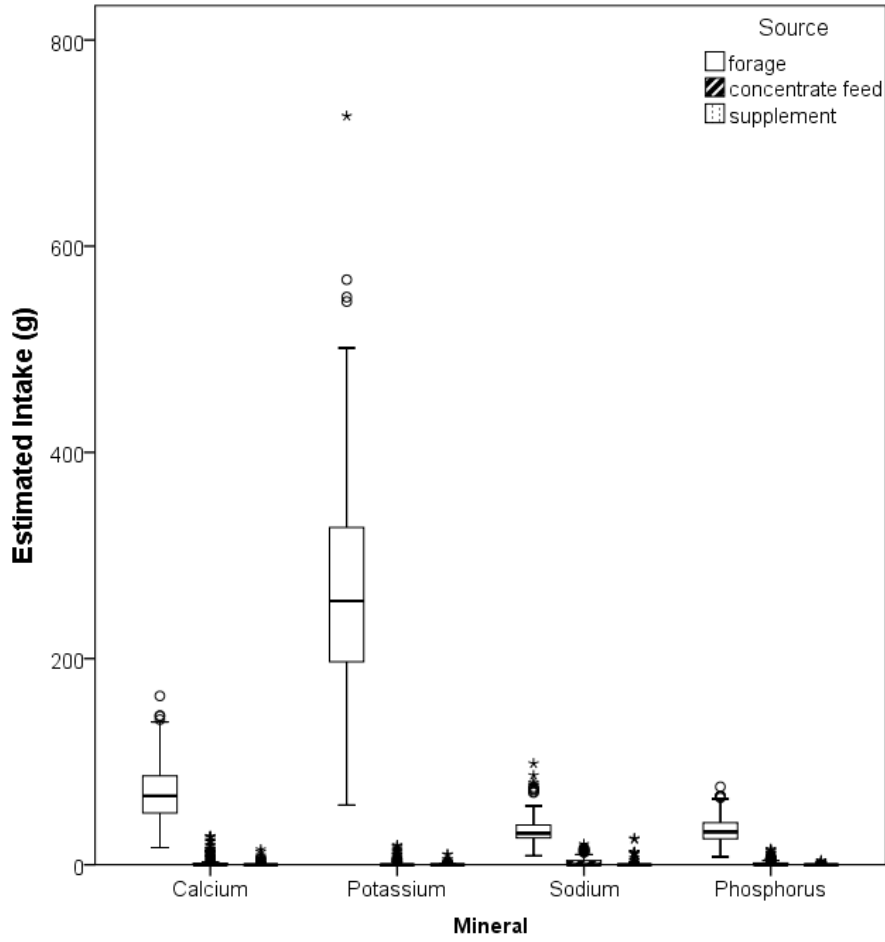
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294 **Figure 2. Daily estimated intake of calcium, potassium, sodium and phosphorus per**  
295 **feed source.**

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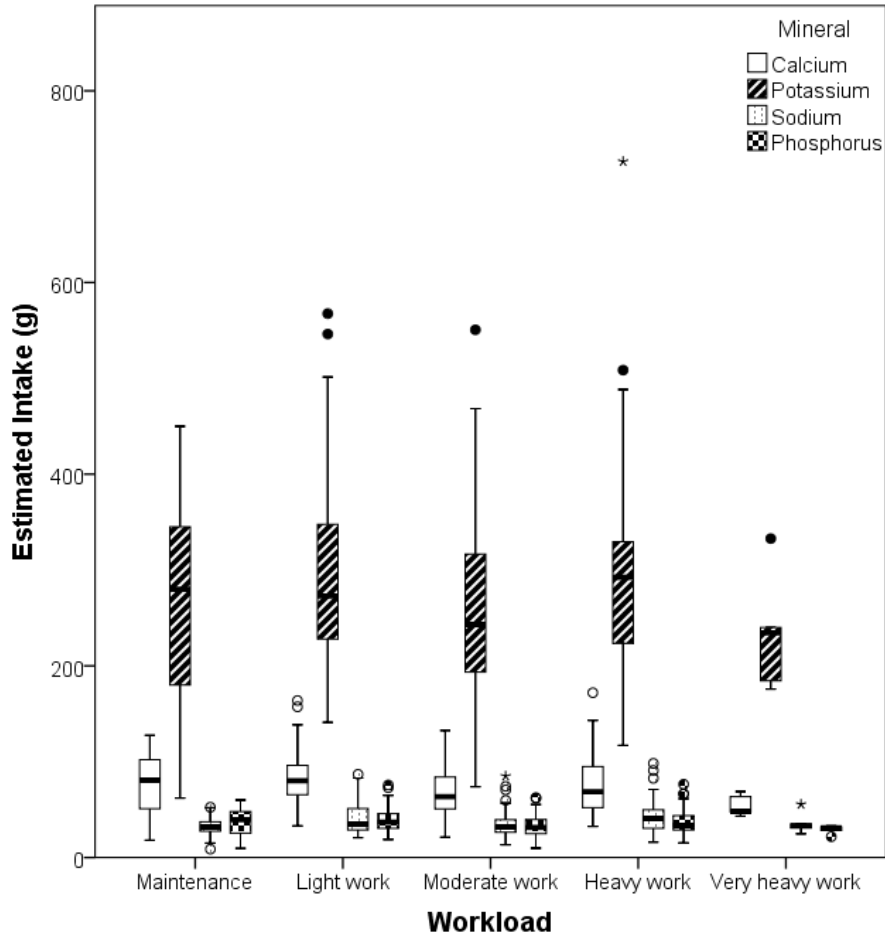
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300 **Figure 3. Comparison of daily estimated intake of calcium, potassium, sodium and**  
301 **phosphorus between horses with different levels of perceived workload.**

302



303