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Original Article

Comparison of the colic incidence in a horse population with or without inclusion of germinated barley in the diet

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Summary

Sprouted cereals have a better digestibility and contain oligosaccharides that act as prebiotics improving and stabilising the intestinal flora. Supplementation with germinated malted barley could help to prevent the occurrence of colic in horses. The objective of this study was to determine if the inclusion of germinated barley as a supplement decreased the incidence of colic in a population of horses. An observational prospective study was designed to record the colic incidence of an equestrian centre horse population in Madrid (Spain). Data were collected during two 21 months periods, only including horses that were maintained at the centre for the whole time. Age, sex, housing and colic events were recorded during Period 1 (control period) and Period 2 (with germinated barley supplementation, Equinocol®). Sixty-three horses were included in the study of which 43 were stabled 12 h/day (Group A) and 20 that lived at pasture all-day long (Group B). Colic incidence of the total population, Group A and group B during Period 1 was 18.1, 23.9 and 5.7 cases/100 horses at risk-year, respectively. With the inclusion of germinated barley, there was a significant decrease in the colic events in the total population (5.4 cases/100 horses at risk-year) and group A (5.3 cases/100 horses at risk-year). It was concluded that supplementation with germinated barley might decrease the appearance of colic in stabled horses. Further investigation is warranted to identify the potentially beneficial substances and the repeatability of the results.

Introduction

Colic is the most common emergency in equine veterinary medicine, with a described incidence of 3.5–26 cases/100 horses at risk-year (Kaneene *et al.* 1997; Tinker *et al.* 1997a; Hillyer *et al.* 2001; Traub-Dargatz *et al.* 2001; Uhlinger 2010; Cook and Hassel 2014). Despite its multifactorial origin, one of the most important risk factors is the nature and quality of the feeding and the quantity and distribution of the daily ration (Tinker *et al.* 1997b; Cohen *et al.* 1999; Hudson *et al.* 2001; Hillyer *et al.* 2002; Archer and Proudman 2006).

Cereals tend to have a low nutritional quality because they have a low protein content, are deficient in certain essential amino acids, have anti-nutritional factors, such as tannins and phytic acid, and low bioavailability of certain minerals, and for that reason, mechanical processing is usually required (Chavan and Kadam 1989; Vervuert *et al*. 2008).

It has been claimed that sprouting cereals offer a viable way to improve the nutritional quality of vegetable proteins for human and animal use (Chavan and Kadam 1989). However, its use in animal feeding has only rarely been investigated (Lorenz 1980). In the early 70s, they were tested in cattle, pigs and poultry to evaluate how the higher levels of essential amino acids and certain vitamins could lead to better nutritional values, but the results were disappointing (Arano 2005; Singh *et al.* 2015).

Cereal germination results in predigestion of seeds, increasing its digestibility and nutritional value (Ayernor and Ocloo 2007; Singh *et al.* 2015). Barley has two main differences compared to other cereals. Firstly, it contains high concentrations of amylase, facilitating the degradation of starch in the feeds that it accompanies. In addition, it contains short-chain fructo-oligosaccharides or FOS, an insulin-type fructan which is considered a prebiotic substance because it facilitates the regeneration of the digestive flora and improves the ration digestibility (Berg *et al.* 2005; Respondek *et al.* 2008; Vendrig *et al.* 2013; Coverdale 2016). Germination facilitates subsequent absorption of fat-soluble vitamins, minerals, biotin or carotenes, improves the digestibility and collaborates in maintaining the intestinal microbial flora due to the presence of fructo-oligosaccharides that could act as prebiotics (Taylor *et al.* 1985; Mizubuchi *et al.* 2005; Tian *et al.* 2010; Respondek *et al.* 2011; Murray 2013).

Our hypothesis was that the inclusion of germinated or malted barley in the daily ration of horses could not only naturally increase the nutritional quality of the ration but could also help to prevent digestive tract diseases.

Materials and methods

Study population

With an observational and prospective design, the colic incidence of the same population of horses at an equestrian centre, localised in the Northern area of Madrid (Spain), was recorded between May 2014 to January 2016 (Period 1) and May 2016 to January 2018 (Period 2). Both periods lasted 21 months.

Only horses that were maintained in the equestrian centre during both periods were included, so the same individuals were compared. During each period, the horses were divided into two groups depending on the housing conditions: those that remained at pasture all-day long

(Group B) and those that were only stabled overnight (Group A). During both periods, the same feed supplier and products were used. Horses' routines and owners did not change during the study period. Only horses that maintained the same owners, similar exercise training and that were not transported out of the centre during both periods were included. There were no significant changes in the centre's personnel, and even the same holiday periods for staff and substitutes were maintained. All horses had free access to water, were vaccinated and dewormed twice a year and received a dental check-up every 6 months.

Feeding in both groups was similar consisting in 1.5–2% bodyweight of straw and 1% bodyweight of a commercial concentrate (**Supplementary Item 1**), divided into two doses per day. During Period 2, supplementation with germinated barley (Equinocol®[1] – **Fig 1**) at a rate of 0.5 kg/100 kg once a day was incorporated into the diet. Its nutritional composition is shown on **Table 1**.

All colic events and the following variables were recorded for each horse: age, sex, and housing conditions, presence and number of colic bouts during each period. Colic events were defined as the presence of clinical signs of abdominal pain (increased heart and respiratory rates, pawing, rolling, etc). All colic events were diagnosed by a veterinarian.

Fig 1: Germinated barley Equinocol® at 6 days.

TABLE 1: Nutritional composition of germinated barley Equinocol® at 6 days

	% w/w
Moisture	85.6
Ashes	2.8
Acid detergent fibre	16.5
Neutral detergent fibre	37.5
Crude fibre	14.4
Total sugar (glucose)	15.9
Starch	18.8
Crude protein	15.9
Crude fat	3.7
Lignin	1.9

Data analysis

A descriptive analysis of the data was performed. Age and number of colic events were considered numeric variables; and sex, presence of colic events and way of life, as categorical variables. Numerical variables followed a normal distribution based on the Shapiro–Wilk test and the Kolmogorov–Smirnoff test. To evaluate the colic incidence and compare it between both periods, the Wilcoxon signed-ranks was used and to compare it between housing management the Wilcoxon rank-sum test was used. To determine the homogeneity of the population in relationship to the sex and age in both groups, the Student *t*-test was used. All statistical analyses were performed with the informatics program SAS .4 and were considered statistically significant when $P \leq 0.05$.

Results

A total of 63 horses were included in the study, of which there were 48 males and 15 females. A total of 43 horses (33 males and 10 females) were maintained on pastures only during the day (Group A) with an average age of 14.4 ± 5.4 years. The group that was maintained on pasture all year long (Group B) included 20 horses (14 males and 5 females) with an average age of 14.5 ± 6.0 years. Age and gender distribution were similar in both groups. None of the horses included in the study showed reluctance to eat the product.

During Period 1, 20 colic events were recorded in 12 horses, resulting in an incidence of 18.1 cases/100 horses at risk-year. In Period 2, only 6 colic events occurred in 5 horses, with an incidence of 5.4 cases/100 horses at risk-year (**Table 2**). None of the colic events required surgery and were all resolvedin the field with medical treatment.

Colic incidence during Period 2 in comparison to Period 1 was lower, with a statistically significant difference ($P = 0.05$). Additionally, the difference in the colic incidence between both periods in horses maintained at pasture only during the day was statically significant ($P = 0.03$). Colic incidence in both periods and groups is shown in **Fig 2**. No differences were noted in colic incidence in horses maintained in pasture all-day long.

Discussion

Hydroponic fodder production methods have been previously described but with current technologies it has become a more efficient and economically competitive technique. In addition, the increase in grain prices, feed production and concern for the environment has led to the development of alternative feeds (Cuddeford 1989).

Hydroponic grains have been studied as feeds in several different livestock species, but no significant

TABLE 2: Total and by groups colic events

	Total colic events	Group A colic events	Group B colic events
Period 1	20*	18**	2
Period 2	6*	4**	2

* ,**Represents significant values ($P \leq 0.05$).

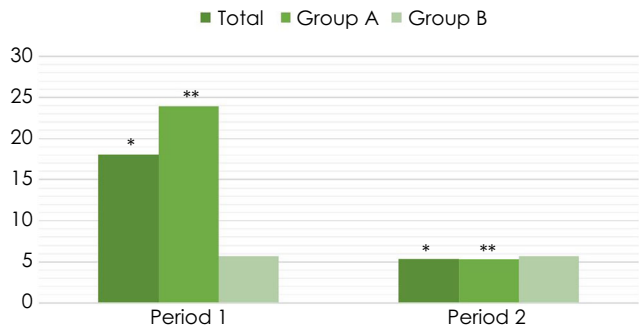

Fig 2: Colic incidence (cases/100 horses-year). *,** represents significant values (P ≤ 0.05).

advantages in this type of product were identified compared to more traditional ones. For this reason, this product has been used as a supplement in this study, since it has been shown to increase digestibility and could provide other advantages (Cuddeford 1989).

The colic incidence recorded during Period 1 (18.1%) was higher than the range previously described in the literature (Kaneene *et al.* 1997; Tinker *et al.* 1997a; Hillyer *et al.* 2001; Traub-Dargatz *et al.* 2001; Uhlinger 2010). However it should be noted that colic incidence is dependent on many factors, one of them being geographical location, and these incidence values originate mainly from the United States and UK, and therefore they may not reflect the true incidence in Spain. Although colic incidences have been anecdotally described in other Mediterranean countries, such as Iran (8.6%) and Egypt (54.6%), to our knowledge, colic incidence in Spain has not been described (Mehdi and Mohammad 2006; Salem *et al.* 2017).

Colic events decreased significantly during the period in which germinated barley was included in the daily ration. The results might support the hypothesis that supplementation with germinated cereals favourably affects the horse's digestive tract, thereby reducing the risk of colic. This result was also significant in horses with access to pastures only during daytime. Stabling in a box is considered a risk factor in the onset of colic (Clarke *et al.* 1990; Archer and Proudman 2006), so this supplementation could be especially valuable in horses with limited access to pasture, counteracting the negative effects of the stabling regime. The incidence of colic in group B remained constant in both periods, showing no improvement with supplementation. However, the population of this group was small and these results should be interpreted with caution. Colic incidence in this group was already low without supplementation which was expected, as increasing time at pasture reduces the risk of colic (Scantlebury *et al.* 2015). The bitter taste may cause initial reluctance to the product, as has been described by other authors (Cuddeford 1989), although the palatability of the product was adequate and often found attractive. In our case, no horse showed problems with the taste of the germinated barley.

The marked improvement in reducing digestive tract problems may be due to the prebiotic function of fructans. Prebiotic compounds have been recently defined as selectively fermented ingredients that allow specific changes, both in the composition and/or activity in the gastrointestinal microflora that confer benefits upon host wellbeing and health (Gibson *et al.* 2004; Proudman *et al.* 2015). Oligofructose, along with lactulose and transgalacto-oligosaccharides, are three oligosaccharides with demonstrated prebiotic properties (Gibson and Roberfroid 1995; Gibson *et al.* 2004). Fructo-oligosaccharides are not hydrolysed in the upper digestive tract, and thus will reach the colon where they are fermented by beneficial types of colonic bacteria (*Lactobacilus* sp. and *Bifidobacteria* sp.), promoting their growth and development and reducing the growing capacity of pathogenic bacteria (*Clostridium* sp.) (Gibson *et al.* 2004; Respondek *et al.* 2008). These oligosaccharides prebiotics had been tested in other livestock species, such as chicken, pigs or cattle, providing evidence of their beneficial effects both in healthy animals and those with digestive disorders and they have been included in the daily rations (Mull and Perry 1994; Bunce *et al.* 1995; Houdijk *et al.* 1997; Oli *et al.* 1998; Fukata *et al.* 1999; Poppy *et al.* 2012). Despite the scarcity of the literature on the use of prebiotics in horses, some studies have shown the beneficial effect FOS supplementation on the digestive tract by decreasing colic incidence (Wolter 1999). Supplementation with FOS decrease faecal *E. coli* counts and pH, while increasing lactate and short-chain fatty acids (Berg *et al.* 2005). It has also been found that FOS supplementation increases total counts of *Streptococci* and lactate–utilising bacteria in the gastric juice as well as increasing the pH, which may potentially diminish the risk of gastric ulceration (Nadeau *et al.* 2000). Furthermore, they increase insulin sensitivity, being a promising component in the feeding management of obese horses (Respondek *et al.* 2008; Respondek *et al.* 2011). A study in racehorses has found that supplementation with amylase-rich malt extract is able to change the intestinal short-chain fatty acids content and microbiome, although functional and clinical implications of these changes are currently poorly understood (Proudman *et al.* 2015). Contradictory results have been found in some studies where FOS from Jerusalem artichoke meal were partly fermented in the upper digestive tract into butyric acid, and it has been related to impairment of the gastric functional mucosal integrity, which may predispose to gastric ulcers (Coenen *et al.* 2006; Glatter *et al.* 2016; Cehak *et al.* 2019). These effects are dose dependent, and more studies are warranted before any conclusions can be reached.

Compared with the grains, when barley is germinated there is a significant increase in the mineral and vitamin content, and they are more efficiently absorbed due to the decreases in enzymatic inhibitors (Chavan and Kadam 1989; Cuddeford 1989; Sneath and McIntosh 2003). The sprouts provide a good supply of vitamins A, E, C and B complex. The vitamin content of some seeds can increase up to 20 times its original value in the course of several days after germination (Chavan and Kadam 1989; Cuddeford 1989).

The occurrence of colic is multifactorial, and multiple risk factors have been described in the literature (Curtis *et al.* 2019). Age, gender, breed and height are known to affect colic rates; in our study using the same horses in both periods eliminated the influence of these factors on the incidence of colic (Cohen *et al.* 2000; Hudson *et al.* 2001; Hassanpour *et al.* 2007; Patipa *et al.* 2012; Suthers *et al.* 2013; Archer *et al.* 2014). The number of hours stabled per day and changes in housing conditions increase colic rates; in our study those horses stabled overnight had a higher incidence of colic (Cohen and Peloso 1996; Cohen *et al.* 1999; Hudson

et al. 2001; Hillyer *et al.* 2002). Management and training are also important factors in colic incidence, therefore, in our study these factors were kept constant throughout the study period for all horses (Hillyer *et al.* 2002). The type of feeding and changes in diet have also been reported to predispose horses to colic (Cohen *et al.* 1999; Hassanpour *et al.* 2007). In this study, the same forage and concentrate were used in all horses and were maintained during both periods. Season and location have also been identified as factors affecting colic incidence. Taking into account that the seasons can influence the incidence of colic, both 21-month periods studied in this article began in March to assess the incidence of colic during the same seasonal pattern (Tinker *et al.* 1997a; Traub-Dargatz *et al.* 2001; Goncalves *et al.* 2002; Archer *et al.* 2004; Archer and Proudman 2006). Although a different study design with different populations of horses in the same time period would reduce the seasonal variability, this non-contemporaneous design was preferred in order to reduce the individual horse risk factor effect. Caretaker and owners were the same during both periods, reducing the influence of potential management changes (Archer *et al.* 2008; Escalona *et al.* 2014).

Despite our design that aimed to reduce most of the potential factors that could affect the incidence of colic, some limitations of the study must be considered. The small number of horses, especially in the pasture all-day long group could have under or overestimated colic incidence. Some described risk factors have not been taken into account in our study and could have affected our results. Clinical history, especially previous colic events, behaviour, such as stereotypies, or administered medications during the study, such as NSAIDs, were not recorded (Hillyer *et al.* 2002; Escalona *et al.* 2014; Scantlebury *et al.* 2015; Scherrer *et al.* 2016; Salem *et al.* 2017). Although most of the risk factors that predispose to colic will have been similar between both periods, some aspects could have escaped our control and affected our results.

In conclusion, germinated barley has been shown to provide easily digestible nutrients for the equine digestive tract and can benefit the intestinal microbiome and health. This study shows a decrease in the colic incidence after the inclusion of germinated barley to the diet and especially in horses with limited access to pasture. Although several confounding factors must be taken into account, our results suggest that supplementation with malted barley could reduce colic incidence and could be recommended in high-risk horses. Further studies with a larger population and more control of known risk factors are required to assess the repeatability of these results, and to evaluate the influence of the geographical area and the housing facilities. Additional studies to evaluate the ideal dose are also needed.

Authors' declaration of interest

No conflicts of interest have been declared.

Ethical animal research

Not applicable.

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Authorship

All authors contributed to study design, data analysis and interpretation. M. Re, I. Romero and J. Blanco contributed to study execution. All authors contributed to the preparation of the manuscript and gave their final approval of the manuscript.

Manufacturer's address

1Equinocol, S.L., Cercedilla, Madrid, Spain.

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Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's website:

Supplementary Item 1: Composition of the commercial horse feed.