NUTRITION & BEHAVIOUR

There continues to be considerable interest in the possible links between diet and behaviour in humans and in various animal species. Horses have not escaped this attention, since the process of domestication has necessitated changes in their freedom and their management and diet that potentially impact upon their behaviour. For instance, the development of stereotypic behaviours such as weaving and crib-biting in stabled horses has been linked with certain feeding practices, most notably high concentrate and/or low forage diets.

WALTHAM® has continued to investigate how diet and feeding regimens can positively modify the behaviour of horses, working with scientists at the the Universities of Bristol, Lincoln and Southampton plus Writtle College and Hartpury Colleges in the UK, and Virginia Polytechnic and State University in the USA.

Figure 11: *Round device with manger.*

This work has explored the behavioural benefits of foraging devices and foraging enrichment for stabled horses, the effects of meal frequency on stereotypic behaviours, the relationships between diet, crib-biting and gastric ulceration, as well as the impact of diet and weaning methods on the behaviour of young horses.

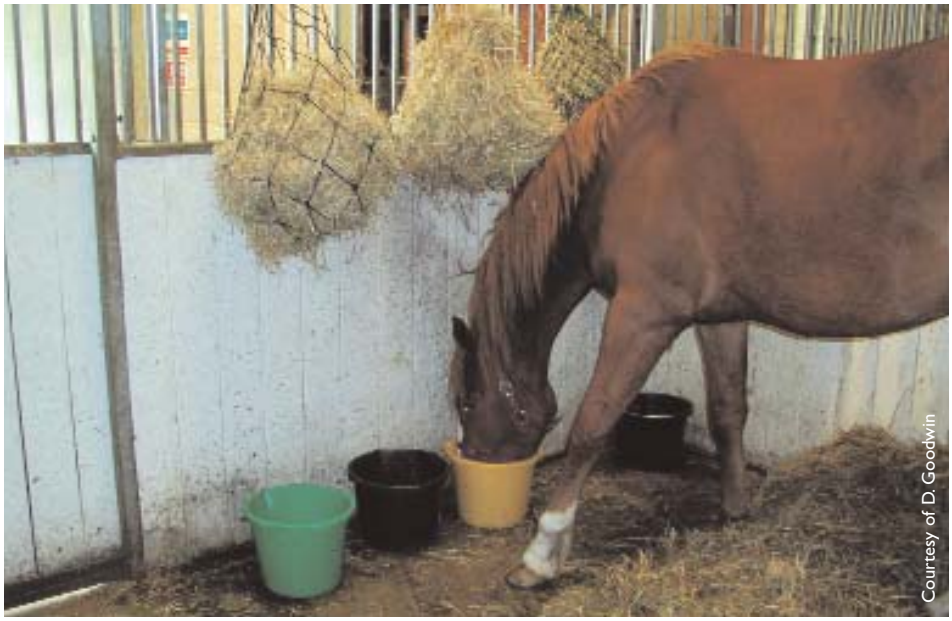

Figure 12: *Multiple forage presentation.*

Environmental Enrichment

Concentrate feeds are usually offered to horses in buckets or mangers and this method of presentation does nothing to slow the rate at which these foods are consumed. Several so-called foraging devices are available commercially and can be used to provide part of the ration in a less easily accessible manner as well as providing sensory stimulation. The ration is placed inside these devices, and horses must either nuzzle the unit or move it with their head or a foot to release food. The one major drawback to these current devices is the fact that they are placed on the floor, raising concerns about the ingestion of foreign materials with the food.

An alternative is to use foraging devices that fit inside feed mangers or buckets and the behavioural benefits of these were evaluated in the first project of this series[1]. Horses were presented with three devices varying in sensory complexity - round, square and polyhedral in design - in either a manger or bucket and their behaviour recorded (*Figure 11*).

All horses foraged successfully from at least one of the devices, but also exhibited some frustration, either biting or pawing at the devices, and frequently removed the devices from the buckets. This was not the case when the devices were placed in feed mangers. The polyhedral design appeared to be the most promising in that it was consistently and repeatedly associated with the longest duration of foraging. This study did show, however, that when the dispensing of pellets is unpredictable, the unpredictability of reward can be a source of frustration.

Horses evolved by consuming a varied and *ad libitum* roughage diet typically high in fibre and this contrasts with the restricted forage diet that most stabled horses are fed.

Provision of a diet that more closely mimics the wild situation should, therefore, enable the expression of more natural behaviours in stabled horses. The second study in this series investigated the behavioural effects of providing multiple forage diets with the aim of developing practical ways of providing forage enrichment[2].

Nine horses were fed either a single forage (hay) or multiple forages comprising three long-chop (ryegrass haylage, ryegrass and timothy haylage, and hay) and three short-chop (dried grass, molassed dried grass and alfalfa) commercially available forages. The short forages were presented in individual buckets, whereas the long forages were provided in separate haynets (*Figure 12*).

Foraging behaviour was significantly more frequent and longer in duration when the horses were fed multiple forages (*Figure 13*). Horses spent significantly longer periods searching for alternative resources when hay alone was fed and stereotypic behaviour was also observed; no such behaviour was seen when multiple forages were fed. While horses sampled all of the multiple forages, they did express preferences for individual forages, with molassed, chopped Alfalfa being the favourite.

These findings confirm that there are behavioural advantages of providing multiple forages to stabled horses. These appear to enrich the environment by offering variety and enabling the expression of foraging behaviours that more closely mimic the patch foraging seen in free-roaming horses.

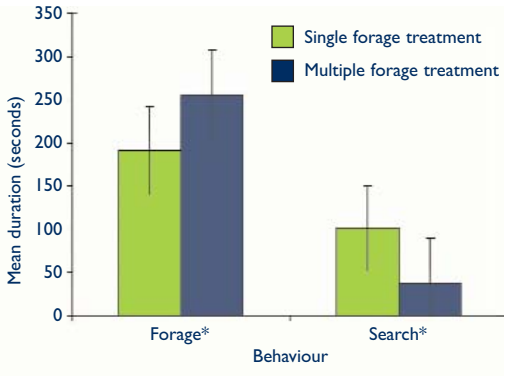

Figure 13: *Mean duration (seconds) of forage and search behaviour during single and multiple forage treatments (± 1 s.d.). *Significant differences; P<0.05.*

Another potential method for enriching the stable environment and reducing stereotypic behaviours is to provide more frequent, but smaller, concentrate meals. This was evaluated by splitting the daily concentrate ration into 2, 4 or 6 equal feeds[3]. Prior to the study, baseline behavioural characteristics were recorded and, while these showed a low incidence of stereotypic behaviours, it was clear that such behaviour was more commonly seen in the afternoon which coincided with there being less forage available.

The incidence of oral stereotypies - defined as repetitive oral activity without ingestive intention, such as sham chewing, tongue rolling, and biting, chewing and licking of stable fittings - decreased as the number of meals increased. There was, however, a concomitant increase in anticipatory-related activities such as weaving and nodding prior to feeding. The incidence of weaving, nodding and oral stereotypic behaviours also increased in the control horses that continued to be fed twice a day.

This study highlights the complexities of trying to modify equine behaviour in a yard situation, where there are multiple stables plus interactions between neighbouring and distant horses. While increasing meal frequency did reduce the incidence of some stereotypies, it actually increased these behaviours in horses that were in visual contact and not fed at the same time.

Crib-biting

The development of crib-biting has been linked to high concentrate and/or low forage diets and it has been proposed that this behaviour is initiated in young horses in an attempt to produce alkaline saliva. This likely represents an attempt to buffer stomach acids when alternative stimuli or opportunities for mastication are limited on high concentrate/low roughage diets. Relationships between crib-biting behaviour and gastric pathology were explored in the next project in this series[4], which also assessed the effects of an antacid diet on both behaviour and stomach condition.

Figure 14: *Endoscopic picture pf part of the stomach of a crib-biting foal.*

Videoendoscopic examination of 15 crib-biting foals revealed their stomachs to be significantly more inflamed, dry and ulcerated than those of normal foals (*Figure 14*). Consumption of the antacid diet for 3 months was associated with a reduction in the number of ulcers and the incidence of crib-biting behaviour. There was a significant correlation between the reduction in crib-biting and the reduction in gastric ulceration.

These results add weight to the belief that crib-biting is initiated in foals in response to more acid stomach conditions, or to increased sensitivity to normal levels of acidity. Altering gastric acidity should, therefore, modify the expression of this behaviour and this was supported by the changes in gastric ulceration observed.

Effect On Foal Behaviour

There have been very few published studies on the effect of diet on behaviour, especially in the young growing animal. This was

further investigated in two final studies. In the first, weanling foals with access to a pasture supplement based on fat and fibre were found to be more relaxed (*Figure 15*) than foals of a similar age fed a supplement rich in starch and sugar during 10 minute preference tests, despite another known weenling always being present in the test environment[5].

These observations were explored in more detail in the second study, in which behaviour was observed every 2 weeks from 2 to 40 weeks of age[6]. Foals grew well on both diets and there were no effects of diet on behaviour prior to weaning.

Immediately after weaning, foals receiving the fat and fibre supplement cantered less frequently, for a shorter duration, and appeared to be more settled than those fed the starch and sugar supplement. The foals fed the fat and fibre supplement also spent significantly more time investigating and less time looking at a novel object, spent less time walking away from a novel person and completed a handling test in a quicker time (*Figure 16*).

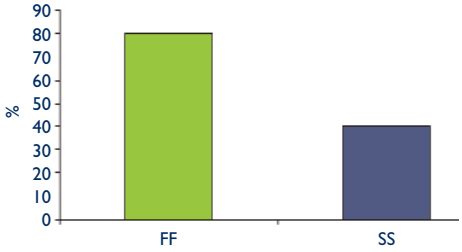

Figure 15: *Percentage of weanlings that appeared relaxed during 10 minute preference tests. FF = fed a fat and fibre rich supplement; SS = fed starch and sugar rich supplement.*

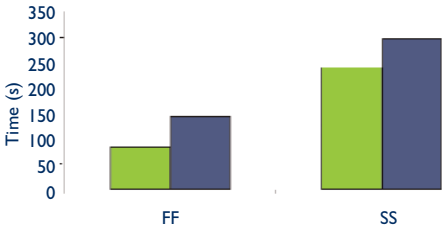

Figure 16: *Time taken for weanlings fed either a supplement rich in fat and fibre (FF) or starch and sugar (SS) to either cross a bridge or a ground sheet.*

Overall, horses fed a fat and fibre based supplement appeared less distressed immediately after weaning and seemed calmer and more inquisitive during a range of temperament assessments. While previous studies have shown that high-starch diets can increase the risk of abnormal behaviour in foals, this is the first research to show that diet can influence behaviour, reactivity and stress responses in normal horses.

Role Of Tryptophan

Currently, much of the interest around diet and nutrition is therefore focused on the areas of temperament and tractability. Preparations containing tryptophan are marketed as calming agents for horses, but data on their absorption and efficacy are lacking. A second project examined the availability of tryptophan from commercial pastes[7]. Tryptophan is an essential amino acid and a precursor of the neurotransmitter serotonin, which is implicated in sedation and inhibition of aggression, fear and stress in humans and various animal species.

Research undertaken in collaboration with the University of Queensland and Charles Sturt University in Australia showed that blood tryptophan levels do increase for around 6 hours following dosing with commercially available pastes (fed at double the recommended levels). The response was, however, dependent upon the background diet, in that higher blood levels were achieved in horses fed solely hay than in those fed hay and oats, which is perhaps contrary to the perceived ideas of oats being 'psychologically' heating. Additional studies are now required to establish whether these responses are associated with any modification of behaviour.

Feeding Behaviour

While great advances have been made in understanding the dietary requirements of horses, as well as the functionality of nutrients, the way in which horses eat and are fed in domestic environments has attracted comparatively little research interest. For humans and domestic pets, eating involves more than simply the ingestion of food. It encompasses facets such as sensory stimulation and social interaction. Proper selection and mastication of food is also essential for the maintenance of digestive health.

WALTHAM® research has continued to explore physiological and behavioural aspects

of feeding horses. The science presented here has explored the design of food selection trials for horses, the use of flavours to improve the acceptance of concentrate feeds, and the inclusion of chaff in concentrate meals.

Side Preferences

In nutritional studies, food preferences are determined by measuring the relative intakes of two food choices positioned beside another. One possible source of error in such studies is the consistent selection of one food based on its position, i.e. left or right, alone. This is termed 'side preference' feeding and was investigated at Nottingham Trent University, UK, by recording food intake and feeding behaviours when the same feed was offered to horses in two separate containers[1].

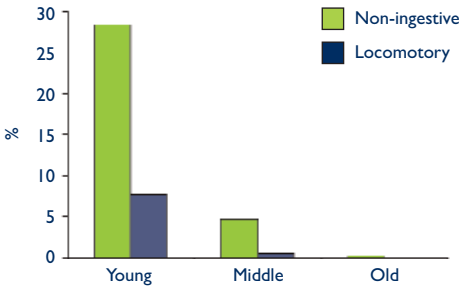

Figure 17: *Percentage of time during a feeding bout that was spent on either non-ingestive or locomotory behaviour in young, middle aged and older horses.*

Eight of the 18 horses in the study (44%) demonstrated development of significant side preferences over time, with an equal number of horses showing a preference for food positioned on the left or right. Interestingly, when the horses were divided into age groups, the incidence of side preference was higher in old (aged 16–22 years) than young (2–4 years) and middle-aged (8–14 years) horses. The strength of the side preference was also greater in the old horses.

The time that horses spent eating also increased with age, whereas the young horses tended to spend more time exploring the feed and the environment rather than ingesting food (*Figure 17*). A reduction in exploratory behaviour with age may explain the observed rise in the incidence and strength of side preferences, since these horses rapidly and exclusively choose to consume one of the feed offerings. These findings have important implications for the design and interpretation of two-choice preference tests, particularly when they are used in middle-aged and older horses.

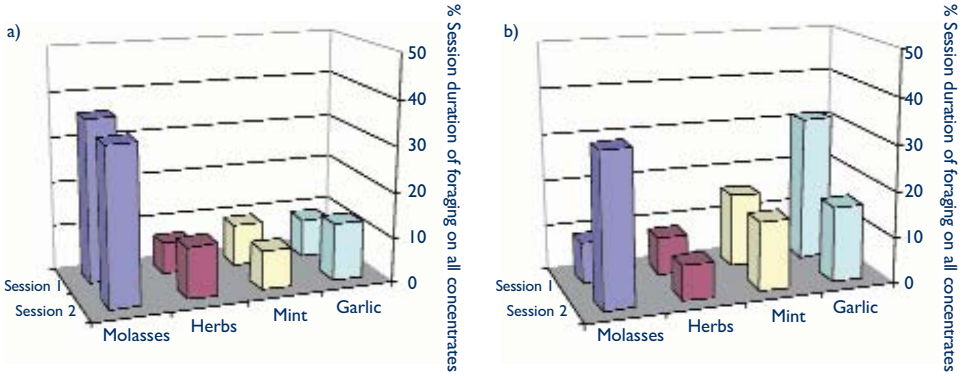

Figure 18: *Sequential selection of flavoured concentrates during multiple choice sessions (percentage session duration of foraging on all concentrates). a) Herb first presentation (Day 4); b) Herb second presentation (Day 6).*

Flavour Choice

Like most grazing herbivores, horses select their food according to its sensory properties, specifically visual cues, odour, taste, texture, availability and variety. There is, however, little published information on the role of flavour in food selection by domestic horses. To address this, the effects of flavour and concentrate formulation on food selection and acceptance were investigated in collaboration with scientists at the University of Southampton, UK.

In the first set of trials[2,3], the acceptance/rejection and quantity and rate of consumption of cereal by-product meals containing 15 separate flavours were assessed. Twelve flavours were universally accepted by the eight horses tested, demonstrating that horses are attracted to a wide range of flavours. This flavour range was in fact wider than that in current commercial use.

The eight most readily consumed flavours were subsequently presented in paired preference tests. From these tests, the flavours were ranked in descending order of preference as fenugreek, banana, cherry, rosemary, cumin, carrot, peppermint and oregano.

In the final part of this study, the consumption of mineral pellets flavoured with fenugreek or banana was found to be greater than that of unflavoured pellets. There was no difference between consumption of the fenugreek- and banana-flavoured pellets. These findings demonstrate that, in the short term at least, flavour does have a significant impact on diet selection, acceptance and consumption.

The effects of sensory variety on the selection and ingestive behaviour of horses was investigated in a separate set of trials[4], which looked at the influences of concentrate formulation, physical composition and flavour. The flavours assessed were molasses, mint, herbs and garlic.

All of the flavoured concentrates were well accepted by the eight horses in the study, but significant changes in concentrate preference were observed between and within trials (*Figure 18*). It was observed that horses repeatedly interrupted the consumption of a concentrate for which they had previously demonstrated a preference, to forage on other diets that were presented in 'multiple taste tests'. This meant that their consumption of the preferred concentrate was always lower in multiple compared with singe test sessions. The total time spent foraging was, however, higher in these multiple sessions.

The basis for switches in preference is likely to reflect an evolutionary adaptation that allows horses to explore and exploit the heterogeneity of dietary resources available. This would allow them to choose a diet of better quality than the average vegetation on offer.

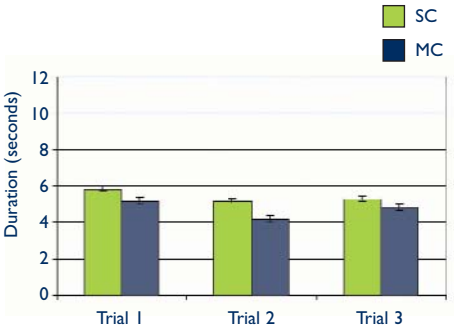

Figure 19: *Mean duration of 'stand behaviour' in all three concentrate trials (square route transformed data). SC = Single concentrate session; MC = multiple concentrate session.*

These trials showed that manipulating a single sensory characteristic of a diet is sufficient to affect both foraging and non-foraging behaviours; for example, horses stood inactive for longer periods when only a single concentrate was available (*Figure 19*).

Providing sensory variety can, therefore, present a means of increasing dietary variety without drastically changing the nutrient content of the ration, and this is likely to be of particular benefit for horses fed restricted or monotonous diets.

Rate Of Intake

One of the major potential drawbacks of concentrate feeds is the rapid rate at which they are consumed by many horses. This is associated with minimal mastication and reduced production of saliva, which increases the risk of digestive upsets such as oesophageal obstruction, gastric ulceration and colic.

To overcome these concerns it has become increasingly popular to feed dried chopped forages or chaff, either as a component of a manufactured product or mixed in with the concentrate at the time of feeding. Despite the popularity of such feeding practices, there has previously been little research on the amounts and lengths of fibre required to promote benefits. In a series of three studies conducted in collaboration with researchers at Nottingham Trent University, UK, and Charles Sturt University, Australia, the effects of chaff length and inclusion rate on concentrate feed intake and behaviour were investigated.

At Nottingham Trent they evaluated the effects of adding 10, 20 or 30% of straw chopped into either 2.5 or 4 cm lengths to a trial pellet fibre mix (containing 10% short cropped lucerne)[5]. Between 1.0 and 1.2 kg of the mix was fed to horses each morning and evening, and a number of parameters were recorded. The rate of chewing remained about the same regardless of the type of food fed, but the type of food had a significant effect on the rate of intake and the total number of chews/kg. Diets containing added straw were eaten significantly more slowly than the normal diet mix, the normal pellets and the trial pellets on their own (*Figure 20*). There was no significant effect of adding 10% straw chaff to the trial pellets with 10% chopped alfalfa, but there was a significant effect of the 20% and 30% addition. While adding more than 20% of the straw chaff had no significant effect, the intake rate did decrease and the time taken to eat the meal increased.

Average food intake times ranged from 7 min/kg on the normal diet to 16 min/kg when the longer chaff was included at 30% volume to the pellet/chaff mix. There was no significant difference between the long and short fibre lengths at any of the three inclusion rates.

These results indicate that including chaff at an overall inclusion rate of 30% or more can lead to longer and slower eating periods, (can be more than double in duration), with a concomitant increase in chewing. This is

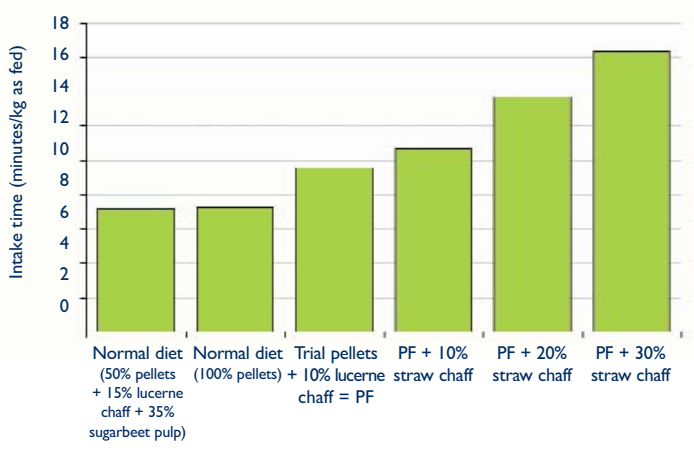

Figure 20: *Time taken to eat 1 kg of each of the diets.*

likely to result in increased saliva production and improved buffering against acid in the stomach following consumption of carbohydrate-rich concentrates.

In a companion study, the effects of including chaff at the time of feeding, as opposed to being included in a manufactured ration, were investigated[6]. Each morning, six geldings were fed a constant meal of oats (3 g/kg bwt) in combination with either longer or shorter ground wheat chaff (4 cm and <2 cm, respectively) at five inclusion rates ranging from 7.0 to 37.5% of the total mixed ration.

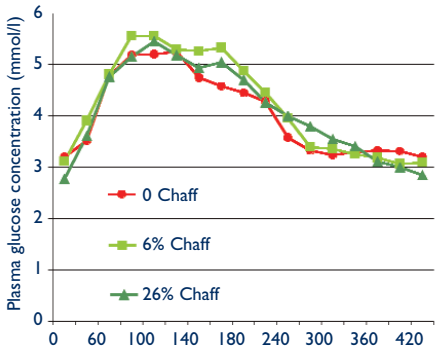

Figure 21: *Plasma glucose concentrations (mmol/l) following feeding a sweet feed meal with and without the addition of 6% or 26% chaff.*

The rate of feed intake declined with increasing addition of chaff, and this effect was maximal when chaff made up 33% of the ration, which is in close agreement with the findings of the previous study. Also in common with the previous study, the rate of food intake was unaffected by chaff length. In the third and fourth studies in this series, the effects of including short (<2 cm) lucerne chaff with either a sweet concentrate mix[7] or an oat meal[8] at 6% and 26% of the total fed ration (6 and 35% addition on top of the core rations) were investigated. Prior to the study starting, researchers determined the rate of intake of 2 kg hay over a 2 hour period each morning. This morning meal was then replaced by the concentrate mix or oats, which were both fed at a constant rate of 3 g/kg bwt. As well as monitoring feed intake, blood samples were collected over a 7 hour period to assess the glycaemic response to the meal.

The rate of feed intake was slowest during the period that hay was fed in both studies (31 g/min). The sweet feed and oats were ingested at about twice the rate of hay (77 and 58 g/min, respectively). The addition of 6% chaff to the concentrate mix did not alter the rate of intake, but an apparent decrease in the rate of intake was seen with 26% chaff (49 and 52 g/min for the sweet feed and oats, respectively), although this was not statistically significant. This was due in part to an increased volume of intake per minute, particularly with the oat meal. This could potentially increase the risk of complications such as oesophageal impaction associated with more rapid feed intake and reduced chewing. There was no correlation between rate of feed intake and the area under the curve (AUC) for blood glucose concentrations (*Figure 21*). The AUC and peak blood glucose level was significantly higher for the sweet feed compared with hay, and there was no significant effect of chaff inclusion on these parameters. Therefore, the addition of chaff seems unlikely to have an adverse effect on starch digestion in the small intestine, in that it does not appear to attenuate the glycaemic response to carbohydrate-rich feeds.

These last two studies, which showed that short Australian chaff at an overall inclusion rate of 26% in the ration does not slow down eating rates significantly, appeared to conflict with the first UK study which showed that 20% chaff inclusion had a significant effect compared with feeding pellets alone. This may reflect differences in the basal meal type. In addition, further investigations, which have yet to be published, have suggested that this apparent difference is most likely due to the size of the meal fed and the length of the observation time in the different studies. This is because it appears that horses do not eat at a constant rate but have a more rapid rate of intake for the first 10–15 mins of a meal and then slow their intake down by as much as a half. The UK study fed smaller meals (1.0–1.2 kg) which were eaten in under 20 mins, whereas the Australian studies fed up to 2 kg and observed the horses eating for up to 45 mins. Therefore, it appears that chaff addition may be particularly effective with smaller meals or early in a larger meal at the time when horses are most at risk of eating too quickly. Clearly, the addition of chaff can have real benefits for horses and further work is required to establish the type of chaff, its fibre length, means of feeding and inclusion rate to maximise these benefits. ■

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