Motivation for hay: Effects of a pelleted diet on behavior and physiology of horses

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ABSTRACT

The natural diet of free-ranging horses is grass, which is typically high in fiber and calorically dilute, however diets for high performance domestic horses are often low in fiber and calorically dense. The aim of the study was to determine the motivation of horses for hay when fed a low roughage diet. Their motivation could be used to determine if low roughage diets compromise the welfare of horses. Eight mares were fed two different diets in counterbalanced order: ad libitum orchard grass hay; a complete pelleted feed (pellets). Each trial lasted three weeks, with a one-week transition period between diets. To determine the motivation of horses for fiber they were taught to press a panel to obtain a food reward. The fixed ratio (FR) was increased using a progressive ratio (1–2–4–7–11–497) technique. When fed pellets, the horses worked for a median FR of 1 (Range = 1–497) to attain pellets, and when fed hay, they worked for a median FR of 25.5 (4–497) to attain pellets. When fed hay, the horses worked for a median FR of 0 (0–0) to attain hay, and when fed pellets, they worked for a FR of 13 (2–79) to attain hay. These results indicate a greater motivation for hay, a high fiber diet, when fed a low fiber diet. The horses spent 10 (5–19.4)% of their time during a 24-hour period eating pellets compared to 61.5 (29–76)% of their time eating hay. Horses spent 58% of their time standing when fed the pellets and only 37% of their time standing when fed hay. Searching behavior (i.e. sifting through wood shaving bedding for food particles) took up 11.5 (1.4–32)% of the horse’s day when fed pellets, but only 1.2 (0–3.5)% of the daily time budget when fed hay. Horses chew more times when eating a hay diet (43,476 chews/day) than when eating a pellet diet (10,036 chews/day). Fecal pH was lower in horses fed the pelleted diet.

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1. Introduction

Horses are grazing animals and, when they cannot graze, behavior and health problems may arise. Wood chewing, a very destructive behavior in which the horses actually ingest the wood of trees, fences, and even walls is associated with a lack of forage or fiber [25]. Low-forage diets have been associated with the development of gastric ulcers [1], which is especially prevalent among racehorses [24], a group of horses commonly fed low-forage diets [3]. Feral and wild horses spend most of their time grazing [4,7,8,21]. Grazing consists of taking a few bites of grass before walking a few steps to a new feeding station. Domestic horses are restrained in stalls and fed hay to which grain is usually added. When more calorically concentrated food is available horses can consume their requirements in a much shorter period of time. This is reflected in the time budgets of horses fed diets differing in fiber content. For example, Willard et al. [25] found that horses fed a hay diet spent 40% of their time eating and 45% of their time standing. Horses fed a concentrate diet in the same study spent only 3% of their time eating and spent 62% of their time standing.

Horses feed a diet low in fiber and high in grain have a greater risk of developing stereotypic behaviors such as cribbing (grasping a horizontal bar and swallowing air), circling the stall, and weaving (standing in one place shifting the weight back and forth) [14,17]. Conversely, more time at pasture is associated with a lower risk of these stereotypes [2,6].

Despite all the problems that arise when horse are restricted in their forage intake, the convenience of concentrated diets and the consequent small amounts of manure encourage most horse owners to feed low roughage diets. The aim of this experiment was to determine if horses develop a “roughage hunger”, that is are they motivated to obtain a high fiber diet. We fed, in counterbalanced order, two diets that are commonly fed to horses—a complete feed and grass hay—and measured the horse’s motivation for each under two dietary conditions.

The main objective of this study was to determine if horses are motivated to obtain fiber when fed a low fiber diet. Secondary objectives were: to determine the effect of diet on behavior of the horses; to determine the chewing rate and total chews per day while consuming diets differing in fiber content, and to measure fecal pH in horses fed a hay and a pelleted complete diet.
2. Methods

2.1. Subjects and facilities

Eight horses were used to investigate the motivation for different feedstuffs and hay. The horses were Thoroughbred (n = 6), Warm-blood (n = 1), and Quarter Horse (n = 1) mares aged 6–14 years and weighing 350 to 550 kg. The mares were acquired as donations to Cornell University.

The horses were housed in 3.3 × 3.3 m stalls which contained an automatic waterer (water provided free choice), a plastic feed bucket with a trace mineral and NaCl block, a rubber feed pan on the floor (if on complete pelleted diet), and wood shavings (9 ft³) as bedding over rubber stall mats. These stalls did not contain any wooden materials with the exception of the shavings used as bedding. The mares were fed at approximately 0700 and 1300; the stalls were cleaned and bedding replaced each morning.

The mares were released daily for 30–120 min in a small dirt paddock (perimeter = 115.7 m) with scattered weeds. The fence of the paddock was also pipe rail. The paddock contained one painted wooden run-in shed at the far end. Horses were their own controls in a cross over design.

The body weight of each horse was accessed once weekly using a weight tape; they were also assessed visually. These observations were used to determine the amount of feed each mare received while on the complete pelleted ration. If they lost or gained too much weight (±10 kg.), their feed was adjusted accordingly.

2.2. Experimental diets

The diets were free choice orchard grass hay (see list of nutrients Table 1), or a complete pelleted feed (pellets) (Bonanza®). The ingredients of the pellets were, in order of weight, soybean hulls, wheat middlings, alfalfa meal, cornmeal, cane molasses, ground limestone, salt, calcium carbonate and distillers dried grain. The pellets were rationed at 1–1.5% bodyweight. Half of the horses received the hay diet first, and half the pelleted diet; there was a one-week transition period during which the first diet was gradually replaced by the second in the hopes of avoiding gastrointestinal upset.

This experiment was approved by the IACUC of Cornell University.

2.3. Test of motivation

2.3.1. Training and testing facility

The training and testing of the horses took place in a stall constructed of pipe rail (2.3 × 1.0 m) located in a separate barn from that in which the mares were housed. The seven weeks of total testing did not include the time it took to train each horse. The time range for training ranged from 1–3 weeks. The horses were operantly conditioned to open the front door of the stall to reach food.

The operant conditioning arrangement consisted of a 10 cm × 10 cm metal panel attached by a hinge to an electrical junction box that was affixed to the upper left hand corner of the inside of the front door of the stocks. When the metal panel was pushed by the horse a small switch with a spring lever located in the box beneath the metal panel was closed, completing a 24 V circuit to an electronic counter. This counter could be preset to a specific number.

Repeated pushes on the metal panel by the horse were counted down from the preset number until 0 was reached, and then a relay was automatically closed that completed a circuit to the solenoid of the latch mechanism on the door. At that time, the door latch unlocked with an audible cue and the door swung open, allowing access to a bucket on the ground with the food reward (either 100 g of pellets or 100 g hay).

2.3.2. Training procedures

The mares were accustomed to the stall and facility by walking them through and around the straight stall, and having them stand quietly in the stall. After each horse was accustomed to the stall, the behavior of pressing the metal panel with her nose was shaped. She was rewarded for first placing her nose by the box (with carrots or apples), then for touching the panel, then for pressing the panel. When the mare learned to press the panel the electronic counter was set to 1 (fixed ratio – FR = 1); she was rewarded only for pressing the panel, which resulted in the buzzer sounding and the door opening, allowing access to the feed (i.e. apples, carrots, or sweet feed) in a bucket on the ground. This was repeated several times at FR = 1, before the counter was set for FR = 2. The horse was then rewarded only after two pushes on the panel. The mares were trained once or twice daily for 15 to 20 min and gradually the FR was increased. Those mares starting on the free choice hay diet were fed only 1 flake (approximately 1 kg) of hay rather than free choice at 0700 before training or testing at 1000 to ensure they would work for the food reward. After training or testing each day the horses were given hay free choice. When the mare successfully completed a fixed ratio of 22 presses in less than 15 min, she was allowed to begin the study.

2.3.3. Testing protocol

The horses were tested twice each week — one day for 100 g of pellets as rewards and one day for as 100 g of hay rewards — for three weeks while fed each diet. Each horse was tested with each reward three times while eating each diet. Testing started between 1000 and 1100 on testing days, and continued until the horse no longer worked for the reward, that is, extinguished. The total amount of time spent on each testing day with each horse ranged from 5 min to 3 h. One or two horses were tested per day in the single testing stall. The horses worked through a progressively increasing ratio (Table 2) each day until they ceased to respond (extinguished). We considered the horse extinguished when she would either: no longer press the panel for her reward (within a time constraint of 15 min), or did not finish the reward within 5 min. The last completed FR of the day was recorded as the FR for the mare on that day. To avoid gastrointestinal disturbance no more than 3.2 kg of reward could be earned per day. In theory the horse could have progressed from FR = 1 to FR = 497 to reach a total of 3.2 kg.

2.4. Behavior

2.4.1. In-stall behavior

The mares were videotaped for 24 h, 3 days each week to assess their behavior while being fed each diet. A Panasonic CCTV Camera (model #WV 8P310) and a Panasonic Time Lapse Video Cassette Recorder (model # AG-6124) were used to record the mares’ behavior. The cameras were mounted on the walls above the stalls. The horses’ behavior was recorded using an instantaneous sampling method every 60 s for 24 h. The mutually exclusive behaviors recorded were: stand, stand resting, eat, search (nosing through the bedding presumably to find small food particles), drink, defecate, urinate, mouth (placing lips or teeth on non-food objects such as buckets or rails), roll, groom-self, walk, lie sternal, and lie lateral.

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Pellets</th>
<th>Hay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude protein</td>
<td>12.5%</td>
<td>12.9%</td>
</tr>
<tr>
<td>Acid detergent fiber</td>
<td>29.0%</td>
<td>32.6%</td>
</tr>
<tr>
<td>Neutral detergent fiber</td>
<td>44.0%</td>
<td>49.9%</td>
</tr>
</tbody>
</table>
2.4.2. Chewing rate

The chewing rates of each horse were also recorded as chews/min during the first 30 min of their afternoon meal twice weekly (6 times/horse/diet). The number of jaw movements was counted from video recording made at close range in real time. Thirty minutes of total chewing of the feed was assessed; if the horse stopped chewing to drink etc., the timer was stopped and started again when the mare resumed chewing. The time the horse spent chewing per min was multiplied times the number of minutes she was eating hay (or pellets) per day.

2.4.3. Behavior in paddock

The mares' behavior during individual turnout (not on a test day) in the paddock was recorded on a handheld computer using the Observer™ program either directly or from video recording. This was done to take detect any abnormal behaviors in the field (weed eating, wood chewing, pawing, windsucking etc.) as well as normal behaviors. Each horse was observed six times while being fed each diet. The outdoor behaviors recorded were: stand, stand resting, search, drink, defecate, urinate, mouth, roll, groom-self, walk, wood-chew, trot, run (canter or gallop) lie sternal, and lie lateral. No food was available to the horses in the paddock.

2.5. Fecal sampling and pH analysis

A single fecal sample was taken from each horse (from the stall floor) on the final day of each diet, either before the one-week transition period to the new diet, or before they were switched back to their normal feeding regime. The samples were frozen for pH analysis at a later date. The samples were thawed at room temperature and placed in a refrigerator overnight before analysis was performed.

Fecal analysis was done using the Waterproof pH Testr 3+ Double Junction, by Oaktron® Instruments (model # 35624-34). The tester was calibrated per manufacturer's instructions to pH 7.0 using Buffer Solution pH 7.0 certified ±0.01 at 25 °C by Fischer Chemicals. After calibration, the pH tester was rinsed in tap water per manufacturer's instructions, dried with a paper towel, and then placed into each fecal sample using moderate pressure, to ensure good contact with probes.

2.6. Statistical analysis

All data from this study was analyzed using non-parametric statistics because the data were not normally distributed and there were a small number of subjects (n = 8) for any given diet. This test was chosen so that we could analyze each week of the experiment, blocked by both horse and treatment. Friedman Two-Way ANOVA was used to analyze the highest response rate (break point) separated by weeks and blocked by horse and treatment (diet consumed and reward offered). Friedman's test determines whether the rank totals determined are significant when the fixed ratio data is converted into ranks (i.e. 1–4, 1 that for which they worked least, 4 that for which they worked hardest).

Data describing the difference in chewing rates while consuming the pellet diet (pellets) and the hay diet were analyzed using the Wilcoxon Signed Rank Test. The total number of chews per day while consuming each diet was calculated and analyzed using Wilcoxon Signed Rank Test. Wilcoxon Signed Rank Test was also used to determine comparative differences between outdoor behaviors observed while the horses were consuming the pellet diet and consuming the hay diet. The pH of fecal samples taken from each horse at the end of the 3-week consumption of each diet was also analyzed using Wilcoxon Signed Rank Test.

The 24-hr time budgets of the horses were determined from the median times the horses spent performing each behavior. The peak and nadir differences of eating behavior across a 24-hour period was also determined using median time spent eating for specific hours for each horse; this was also analyzed using Wilcoxon Signed Rank Test.

3. Results

3.1. Test for motivation

When horse is accounted for in the block (week), there was a significant treatment (diet) effect (p < 0.001) for each of the three weeks (Table 2). When treatment was accounted for in the block, there was no significant difference between horse preferences (p = 0.05). This indicated that the outcome of this experiment was not dependent on the individual horse’s willingness to press the panel; horses that pressed many times for one food pressed many times for the other, but the difference was in the same direction as that of horses who pressed a small number of times. The diet the horse was eating in comparison to the food reward offered determined the outcome. In other words some horses worked harder than others, but the direction of change was the same.

Data for test of motivation were graphed as the highest median fixed ratio (FR) the horses completed for each treatment. We could rank the number of responses, from lowest to highest as: Eat Hay, Reward Hay (HH) < Eat Pellets, Reward Pellets (PP) < Eat Pellets, Reward Hay (PH) < Eat Hay, Reward Pellets (HP) (Table 2 gives the data for responses made for each reward during each week of testing. In summary, the horses did not work for hay when hay was available; the median (and quartiles 1, 2, and 3) amount of hay eaten was 0 (0, 0) g, but when the horse was eating pellets there was an increase in motivation for hay; the median amount of hay earned was 500 (200, 500, 767) g. When the horse is eating hay the median amount of pellets earned was 800.5 (684, 800.5, 1350) g. When the horse was eating pellets the amount of pellets earned was 67 (0, 67, 320) g.

3.2. Behavior

3.2.1. Behavior in the stall

The 24-hour behavior for each horse was recorded as percentage of time spent performing a specific behavior (Fig. 1). Horses spent a median of 10 (8.2, 10.1, 12) % of their time over a 24-hour period consuming pellets compared to a median of 64 (54.3, 61.5, 77.8) % of their time consuming hay. The horses spent significantly more time consuming hay than consuming pellets (p = 0.008). For standing behavior (stand resting + standing) horses spent a median of 58 (54.5, 57.9, 61.7) % of their time standing when eating the pellet diet and 36.6 (34.8, 36.5, 41.4) % of their time standing when eating the hay diet, significantly less that while eating pellets (p = 0.008). In-stall searching behavior (i.e., sifting through wood shaving bedding for food particles) took up approximately 11.5 (6, 11.5, 15) % of the horse’s day while eating the pellet diet compared to a median of only 1.2 (0.6, 1.2, 2) % of the horse’s daily time while eating the hay diet. Horse spent significantly more time searching when fed the pellet diet than they did when fed the hay diet (p = 0.008).

Table 2

<table>
<thead>
<tr>
<th>Median (FR completed) for treatment group</th>
<th>Week</th>
<th>HH</th>
<th>HP</th>
<th>PH</th>
<th>PP</th>
<th>Friedman's test</th>
<th>df</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>1</td>
<td>25.5</td>
<td>4</td>
<td>1</td>
<td>20.66</td>
<td>3</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1</td>
<td>25.5</td>
<td>14.5</td>
<td>1.5</td>
<td>16.92</td>
<td>3</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>1</td>
<td>41.5</td>
<td>12</td>
<td>1</td>
<td>15.8</td>
<td>3</td>
<td>=0.001</td>
</tr>
</tbody>
</table>

HH = diet is hay; reward is hay. HP = diet is hay; reward is pellets. PH = diet is pellets; reward is hay. PP = diet is pellets; reward is pellets.
There were two peaks of eating per day when the horses were fed pellets (Fig. 2) and eating fell to zero by 2200 h. This indicates that the horse not only spent less time eating per day, but also concentrated that eating in two distinct meal times rather than eating a little each hour as they did when eating hay. In contrast when eating hay the horses ate fairly continuously with a nadir of 30% (p < 0.05). Searching behavior and standing also showed variation with hour, with a trend toward differences associated with diet.

3.2.2. Chewing rate
Wilcoxon Signed Rank Test was used to determine the relative differences between chewing rate while eating pellets (median 60.9 range [64.3–81.1] chews/min) versus chewing rate while eating hay (median 59.2 [55.3–67.1] chews/min). The chewing rate for eating pellets was significantly faster than the chewing rate for eating hay (p = 0.01).

Analysis of the median time spent eating each day from 24-hour in-stall behavior observations (Fig. 2) showed that horses spent 10% of their day eating a pellet diet and 51% of their day eating a hay diet. If we extrapolate these data for each horse with the median chewing rates for each of the diets and the amount of time spent engaged in eating behavior for a 24-hour period, we found that horses performed 10,036.8 chews/day eating pellets and 43,476.5 chews/day eating hay. When this is compared using the Wilcoxon Signed Rank Test, we find that this comparison is statistically significant (p = 0.01). Horses chewed fewer times per minute consuming a hay diet compared to the number of chews per minute consuming a pellet diet. However, they spent more time each day chewing a hay diet than chewing a pellet diet.

3.2.3. Behavior in the paddock
Horses spent a median (quartiles) of 47.5 (38.9, 47.5, 63.8) % of the time searching during outdoor turnout when eating the pellet diet compared to a median of 32.4 (8.1, 32.4, 50.1) % of the time searching when eating the hay diet. Standing occupied 25 (13.9, 24.4, 32.1) % of the time during outdoor turnout for the horse when it was fed the pellet diet and 36.3 (24.8, 36.3, 47.4) % of the time when the horse was fed the hay diet. Horses spent 12.3 (7.6, 12.3, 17.2) % of the time moving (i.e. walking, trotting, and galloping) during outdoor turnout when fed the pellet diet compared to 19.1 (6.7, 19.1, 25.1) % of the time moving when fed the hay diet. There were no significant differences between outdoor observations while eating the pellet diet when compared to the same behaviors while eating the hay diet.

3.3. Fecal pH analysis
The median pH of fecal samples obtained when the horses were fed the pelleted diet was 6.27 (6.0, 6.3, 6.41) %. When horses were fed the hay diet they had a median pH of 6.62 (6.54, 6.62, 6.83) %. The pH difference of hay versus pellets was shown to be statistically significant (p = 0.01). After 3-weeks of diet consumption, horses had a more basic (higher pH) when fed the hay diet than when fed the pelleted diet.

4. Discussion
The horses of this study were motivated to work for hay when they were being fed a pelleted diet (median FR = 12), but not motivated to work for hay (median FR = 1) when they were being fed hay. Horses do have a hay or fiber appetite indicating that they can respond to a lack of long stem fiber with behavior that leads to more long stem fiber in their diet.

The primary motivator for increased responding for hay is a preference for fiber ingestion or chewing behavior, but the preference for the diet the horse is not presently eating is a secondary motivator. The horses did show a preference to work for the diet they were not currently eating- there was greater motivation to work for pellets when eating the hay diet, than when they were being fed the pelleted diet. Thorne et al. [23] and Goodwin et al. [9] have shown that horses have sensory specific satiety for food, choosing to eat more of a novel food than they would eat if the food were familiar. Horses have a strong sweet preference [11,20]. The molasses in the pellets probably contributed to their willingness to work for pellets. Ninomiya et al. [16] have shown that horses will work harder for a grain than for a hay reward.

Searching behavior (i.e. sifting through wood shaving bedding for food particles) occupied 12% of the daily time budget when the horses were fed the pelleted diet. This differs significantly from time they spent searching when fed the hay diet (1%). The marked increase in time they spent searching when fed the pelleted diet could be attributed to several factors. The horses may have been searching for pellets that had been spilled from their rubber feed pans while eating the pelleted diet. This searching behavior may also be mimicking the grazing behavior of pasture kept horses. Lastly, the horses may have been ingesting the wood shaving bedding. Due to the quality of the video recording and the camera angle it was impossible to determine if the horses were eating or simply moving the wood shavings, but in an earlier study of ponies consuming a pelleted diet we were able to observe the animals eating wood shavings [12], Boswinkel et al. [3] also noted that consuming bedding increased when horses were fed a low fiber diet. Willard et al. [25] observed horses to spend 11% of their time chewing wood when fed a concentrate diet compared to only 2% of the time chewing wood when fed a hay diet. The horses in our study
were not able to chew wood since they were housed in stalls made from non-wood materials (metal and concrete). The consumption of wood shavings may serve as a replacement for wood chewing.

The proper chewing of food aids in its preparation for efficient digestion; smaller particles with increased surface area provide an increased area upon which digestive enzymes and microbes can act [15]. There have been a few previous studies on the chewing rates of horses. The chewing rate was estimated during grazing [8]. Janis et al. [13] in an earlier study from this laboratory compared the chewing rates of horse eating hays of different fiber contents. The rate of chewing grass hay – 68/min — is similar to that found in this study. Bonin et al. [5] also found that the chewing rate for eating pellets is significantly faster than the chewing rate for eating hay. Using the median time spent eating each diet we determined that horses chew a significantly more frequently when fed an all hay diet (10,036.8 versus 43,476.5 chews/day). The significance of this is not only in mastication of food, but also in saliva production. Horses salivate only when they chew; therefore the more chewing the more bicarbonate is delivered to the gastrointestinal tract. This could account for the lower prevalence of ulcers in horse fed hay.

Oropharyngeal stimuli such as chewing can elicit satiety in sham-fed ponies with esophageal fistulas [19]. Sham-fed ponies with esophageal fistulas showed normal satiety behavior after being allowed access to a meal (of which only 10% reached the stomach due to the placement of the fistula), however the inter-meal interval was reduced, due in part to the lack of stimuli on the gastrointestinal tract of digested nutrients [19]. The difference in the number of chews per day of the horses in our study may contribute in part to the increased searching and mouthing behavior observed in the horses. The decreased number of chews per day by the horses when fed the pelleted diet may have caused them to seek other oropharyngeal stimuli and to be motivated to work for chewable food rewards when tested in the operant conditioning stall.

Horses and ponies confined in stalls and given free access to feed engage in meal patterns similar to those seen in grazing animals.Ralston et al. [18] found ponies to spend 38% of a 24-hour period eating a complete pelleted ration offered to them ad libitum. These ponies consumed this diet in 10 meals throughout the 24-hour period.

Fecal pH was measured in this study as an approximation of cecal pH. Cecal pH can be determined only in cecal-fistulated or cannulated horses; the measurement of fecal pH is a non-invasive approximation. A study by Willard et al. [25] found correlations between changes in fecal pH when horses were fed different diets and changes in behavior. The differences in fecal pH found after 3-weeks of diet consumption in the current study were significant. The fecal pH was more acidic when the horses were fed the pelleted diet. This could be attributed to the increased fermentation of the soluble carbohydrates of the pelleted diet due to the increased rate of passage of the small-pelletted particles [12]. There is a spillover of concentrates into the hindgut affecting the efficiency of the microbial population for fiber fermentation. When fecal pH was measured in horses fed a concentrate diet, it was shown to be significantly lower 4, 5, and 6 h after feeding than for horses fed a hay diet [25]. This difference in pH was shown to influence behavior, wherein horses fed the concentrate diet spent significantly more time chewing wood and in coprophagy [19,25].

Although we focused mainly on the fiber differences between the two diets (Table 1), there were also differences in protein, micronutrients, fat, etc. It has been shown that the digestibility of nutrients show associative effects [22]. Crude fiber digestion is significantly (P<.01) depressed when pellets are fed to horses as compared with loose hay [10].

This study set out to answer three main questions: what motivation do horses have for fiber when fed a diet of grass hay and when fed a complete pelleted feed? The horses showed a hunger for fiber within the first week of eating the complete pelleted feed, and that hunger did not increase over the subsequent weeks. The horses were more motivated to work for a novel diet then to work for the diet they were already being fed. There were dietary induced behavior differences in the home stall. During 24-hour in-stall videotaped observations, the behavior changes observed were most apparent in eating, standing, and searching behavior. When horses were fed the hay diet, they spent the majority of their time eating compared to less time spent eating when the pelleted diet was fed. When fed the pelleted diet, horses spent the majority of their time standing and searching.

5. Conclusion

A reduction in fiber in the diet has a major impact on the behavior and physiology of horse. Using operant conditioning, we were able to show that horses are motivated to work for hay (higher fiber), only when fed a low fiber diet, indicating a behavioral need for chewable fiber.

References