A Review of Dietary Fat Supplementation in Horses with Exertional Rhabdomyolysis

Erica C. McKenzie, BSc, BVMS; Stephanie J. Valberg, DVM, PhD; and Joe D. Pagan, PhD

Two forms of exertional rhabdomyolysis commonly respond to changes in diet and management. Unfit horses with polysaccharide storage myopathy benefit from daily exercise, removal of high-starch concentrates, and addition of fat to provide a moderate caloric intake. Fit horses with recurrent exertional rhabdomyolysis can maintain a high caloric intake if dietary starch is reduced and the ration is heavily supplemented with fat. Authors’ addresses: Department of Clinical and Population Sciences, College of Veterinary Medicine, University of Minnesota, St. Paul, MN 55108 (McKenzie, Valberg); Kentucky Equine Research Inc., 3910 Delaney Ferry Road, Versailles, KY 40383 (Pagan). © 2002 AAEP.

1. Introduction

Dietary fat supplementation has become a popular means of providing a highly digestible and dense energy source for horses. Proposed advantages of fat supplementation in horses include decreased use of energy for heat production, enhanced performance, alterations in skeletal muscle metabolism with exercise, decreased feed and water requirements, a calmer temperament, and improved body condition and hair coat.1–5 Recently, dietary fat supplementation has been advocated for chronic exertional rhabdomyolysis as a convenient and effective method of control. However, there is significant controversy regarding the amount and form of dietary fat required, the length of time for clinical improvement to occur following supplementation, and the necessity of additional management changes to maximize the success of dietary manipulations. This review briefly describes the characteristics of chronic exertional rhabdomyolysis, provides practical recommendations for dietary fat supplementation in these horses, and describes additional management strategies that should be applied to maximize the benefits of dietary fat supplementation. A general overview of the current research that has led to these recommendations is included.

2. Standard Equine Diets

The standard equine diet is normally very low in fat and high in nonstructural carbohydrates (NSC) and neutral detergent fiber (NDF). Most equine diets usually contain only 2–3% fat by weight.6 In addition, the crude fat supplied by forage tends to be poorly digestible, as it is contained in the form of plant pigments.7 The NSC component of the diet consists mostly of simple sugars and starch and may be as high as 40–50% of high-energy diets. The NDF portion describes cell wall components and should constitute at least 25% of any equine diet.8 The NSC portion of dietary analysis can therefore be
used as a rough estimate of the starch and sugar content of a feed, and is calculated as:

\[ \text{NSC} = 100 - \text{moisture} \% - \text{CP} \% - \text{EE} \% - \text{NDF} - \text{ash} \% \]

Cereal grains consist of 45–65% NSC (% as fed), and forages range from 6% (straw) to 22% NSC (alfalfa). However, it is important to realize that NSC does not necessarily correlate well to the digestible energy (DE) provided by that particular feed. For example, molasses is ~60% NSC and oats ~46% NSC. However, oats provide ~1.7 MJ more DE per kilogram than molasses due to the considerably greater water content of molasses.\(^8\) Fat is extremely energy dense and supplies ~2.5–3 times the DE of common cereal grains. However, when feeding supplementary fat it is important to distinguish and specify the amount of fat contained in the diet based on the percent weight of the total ration or concentrate portion of the ration, versus the percent amount of DE fat provides in the ration. For example, if 7% of the total ration by weight is fat due to supplementation with rice bran (20% fat content), ~20% of the DE of the ration will be provided by fat. Rice bran supplies 1.72 Mcal/lb of DE, vegetable oils provide ~4.08 Mcal/lb of DE (at 1.92 lbs/qt), and animal fat provides 3.61 Mcal/lb of DE (at 1.8 lbs/qt).\(^9\) Distinguishing whether the percent fat value in the ration represents percent weight or percent DE will avoid confusion and incorrect feeding of supplementary fat.

Feeds that have a high NSC content elicit a more dramatic postprandial glycemic response with greater peaks in blood insulin and glucose concentrations due to the rapid digestion and absorption of glucose from the small intestine. Feeding a source of fat with cereal grains has been shown to stabilize blood glucose and insulin concentrations, avoiding the peak postprandial glycemic responses observed with sweet feed alone.\(^10\) It is believed that significant postprandial glycemic responses may be associated with exacerbation of exertional rhabdomyolysis in horses with polysaccharide storage myopathy, and may potentially be responsible for aberrant behavior in horses fed a high-starch diet.\(^8,11\)

3. Pathophysiology of Chronic Exertional Rhabdomyolysis

Chronic episodes of exertional rhabdomyolysis in light breed horses commonly result from one of two forms of heritable muscular disease: polysaccharide storage myopathy (PSSM) and recurrent exertional rhabdomyolysis (RER). PSSM most frequently affects Quarter Horses, Paints, Appaloosas, and other breeds. It is attributed to enhanced insulin sensitivity and subsequent accumulation of muscle glycogen and variable amounts of abnormal amylase-resistant polysaccharide in Type II skeletal muscle fibers.\(^12-14\) The disorder equine polysaccharide storage myopathy (EPSM) in draft horses is not covered by this review. Although these horses also have a glycogen storage disorder, many of the described signs of EPSM such as normal serum creatine kinase (CK), difficulty backing, difficulty holding up limbs for the farrier, a shivers-like gait, and loss of muscle mass differ from exertional rhabdomyolysis.\(^15\) EPSM in draft horses is reportedly also responsive to dietary fat supplementation.\(^15\) RER, which usually affects Thoroughbreds, Standardbreds, and potentially Arabian horses, results from a stress-related disorder in muscle calcium regulation.\(^12,16\) Both conditions present as chronic episodes of muscle pain and necrosis with exercise, resulting in elevations in serum CK and aspartate transaminase (AST) activity.\(^12\) Exertional rhabdomyolysis is commonly diagnosed based on history, clinical signs, and documentation of inappropriate elevations in serum AST and CK activity with exercise. Examination of frozen sections from biopsy samples of the middle gluteal or semimembranosus muscle helps to differentiate PSSM from RER.\(^13\)

4. Epidemiology of Chronic Exertional Rhabdomyolysis

PSSM does not appear to have a distinct gender predilection. It occurs in unfit horses in good body condition that usually have a calm demeanor. Horses often begin having episodes of rhabdomyolysis at the beginning of training with very mild exertion or after disruption or cessation of their exercise routine. Serum CK activity is frequently persistently elevated in stall-confined PSSM horses.\(^12,17,18\)

In contrast, RER is most frequently seen in fit, young fillies with very nervous temperaments. RER affects ~5% of racing Thoroughbreds, and episodes of rhabdomyolysis tend to increase in frequency as the degree of fitness increases, in contrast to PSSM horses.\(^12\) Resting serum CK activity in RER horses is usually normal unless a recent episode of rhabdomyolysis has occurred.\(^12,17,19\) Lack of routine daily exercise and a diet high in starch are predisposing factors for episodes of rhabdomyolysis in both diseases.

5. Dietary Fat Supplementation in PSSM and RER

Dietary fat supplementation has significant beneficial effects in both PSSM and RER, despite the distinct differences in the pathophysiology of these two conditions.\(^12\) In PSSM, even a minor amount of fat supplementation by feeding a low-to-moderate caloric diet composed of grass hay and a fat supplement (3.5 lbs of rice bran) fed to horses with PSSM decreased skeletal muscle glycogen concentrations within 3 wk.\(^11,20\) Minor amounts of fat supplementation therefore appear to provide specific protective effects in horses with PSSM through effects on glucose metabolism and glycogen synthesis.\(^21\) Improvement in clinical signs of muscle stiffness,
However, required the addition of incrementally increasing amounts of daily exercise over 1 mo.  

In horses with RER, the reasons for the beneficial effects of fat supplementation are not thoroughly understood. In contrast to PSSM, in horses with RER fat supplementation only has a significant beneficial effect when the total caloric intake of the diet is high. RER resembles the disorder malignant hyperthermia in which muscle necrosis occurs in genetically susceptible individuals in response to stress and excitement.  

High-calorie, high-starch diets are known to make horses nervous and these types of diets increase the amount of muscle damage that occurs with RER. Recent research demonstrated that RER horses fed a high-energy diet (28.8 Mcal/d) composed mostly of starch had significantly greater post-exercise serum CK activity compared to one of two isocaloric lower energy diets (21.4 Mcal/d) where calories were provided largely as either starch or as fat. In a subsequent trial, post-exercise serum CK activity was again significantly elevated (>3000 U/l) when horses consumed a high-starch diet (28.8 Mcal/d) but was within normal range (<400 U/l) when they consumed the same high-calorie intake as a low-starch/high-fat diet (20% of the calories supplied by fat). These findings suggest that the beneficial effects of fat supplementation in RER horses could be the result of exclusion of dietary starch rather than specific protective effects of high dietary fat. In both trials RER horses had lower resting heart rates and were more tractable when consuming the high-fat diet. Given the close connection between a nervous temperament and tying-up in RER horses, modulating anxiety and nervousness by reducing dietary starch and increasing dietary fat may decrease predisposition to RER by making these horses calmer prior to exercise.  

Studies in normal horses have demonstrated lower serum cortisol concentrations with exercise in fat-fed horses, which may be further indication of decreased psychological stress on a fat-supplemented diet. 

6. Available Fat Sources  
The major sources of fat available for supplementation of the equine diet are animal-based fat (tallow or lard) and vegetable-based fat, including vegetable oils and rice bran. Vegetable oil is highly unsaturated, very digestible (85–90%), and very energy dense because it consists of almost pure fat.  

Oils that can be used for supplementation include corn, soy, peanut, coconut, safflower, linseed, flaxseed, and canola. Corn oil is usually the most palatable, although soy oil is also commonly accepted. Oil is usually best mixed with the concentrate portion of the ration. Oil is energy dense and cheap but has the disadvantages of being messy, unpalatable to some horses, prone to rancidity in warm temperatures, and difficult to feed in large amounts. Surveys have also demonstrated that owners and trainers prefer to use rice bran or commercial fat-supplemented feeds, compared to oil or animal fat. However, oil is an effective way to increase daily energy intake and may be an economical method of supplying fat to horses not requiring a large amount of supplementation. Additional vitamin E (600–6000 IU/d) should be fed to horses receiving corn oil in the diet to counteract the increased oxidant stress of such diets.  

Animal fat is variable in digestibility (50–90%) and frequently cheaper than vegetable-based products. However, because it is more saturated it tends to solidify at room temperature and may need to be melted for top dressing. It can also be purchased in a more convenient powdered form. Some horses will find animal fat sources unpalatable.  

Rice bran and its products are palatable to most horses and contain ~20% fat as well as vitamin E. Commercial rice bran products occur as powder or an extruded pellet, and are considerably more stable in warm temperatures compared to animal fat and vegetable oils. Commercial rice bran-based products are widely available and are either balanced for calcium and phosphorus or have a recommended mineral supplement that should be fed with them to balance the naturally high phosphorus content. It has been suggested that rice bran does not contain enough fat to be fed effectively for chronic exertional rhabdomyolysis because of a moderate NSC content. However, 6–8% of the NSC portion of rice bran is not composed of starch and is not digested by the horse, and controlled and field studies by the authors have shown that this product produces little postprandial glycemic response. Feeding 1.1–5 lb/d of rice bran or rice bran-based products (Re-leve) to both PSSM and RER horses has resulted in significant improvement in their disease. 

At present there is little information on the effect of different forms of fat on exertional rhabdomyolysis. A study of healthy horses using various sources of fat found that rice bran supplying 17% DE as fat lowered heart rates and plasma lactate accumulation during exercise when compared to a similar amount of corn oil. The authors’ studies have also found rice bran to have a significant effect in lowering pre-exercise heart rates in RER horses, suggesting that rice bran may be an ideal fat supplement for these horses. 

7. Amount of Fat to Feed  
Feeding fiber is a fundamental part of the equine diet, and all horses should receive a minimum of 1.5% of their bodyweight in forage per day. The amount of dietary fat supplementation required to control exertional rhabdomyolysis is, however, controversial. Part of this controversy may arise when the two disorders PSSM and RER are not distinguished. Many PSSM horses do well on a lightly fat-supplemented, low-starch/low-calorie diet if they are exercised regularly, whereas RER horses only seem to benefit from fat supplementation when they require a high-calorie intake. These observations
refute the recommendation that fat supply a minimum of 25% of the daily caloric intake. The most important decision to be made for horses with PSSM and RER is what the necessary caloric intake is to maintain them at an appropriate weight and level of conditioning. Once their caloric needs are assessed then a diet should be designed with an appropriate amount of fat and starch. Feeding all horses with exertional rhabdomyolysis a minimum of 25% of the daily caloric intake as fat is not always appropriate and may result in problems with weight gain or poorly palatable diets.

In Quarter Horse-related breeds, PSSM can usually be managed with grass hay or mixed hay (half alfalfa and half grass/oat or brome hay) and a fat supplement that is balanced for vitamins and minerals. Starch should be decreased to <10% of DE by eliminating grains, molasses, and corn. Rice bran can be gradually introduced into the diet as loose bran or as a pelleted feed. Some horses that will not eat loose bran will consume pelleted forms of rice bran. Owners should understand that it is actually beneficial when horses consume a supplement such as rice bran at a slower rate than a concentrate such as sweet feed, because it reduces rapid absorption of starch.

Depending on the caloric requirements of the horse, 1–5 lb of rice bran can be fed but must be combined with a reduction in dietary starch to <10% of DE. An alternative source of fat is corn oil added to alfalfa pellets. An upper limit of 600 ml of oil per day is recommended, and additional vitamin E should be added to the diet. Supplying fat at 6–10% by weight of the entire ration to PSSM Quarter Horses (unless a higher energy intake is required for exercise) is likely quite sufficient for managing PSSM, and further benefit from more fat has not been demonstrated in controlled trials. Note, however, that none of these diets will result in clinical improvement of muscle stiffness and exercise tolerance in PSSM horses without changing the amount of daily exercise and access to turnout.

Thoroughbreds with frequent episodes of rhabdomyolysis are usually being fed 5–15 lb of sweet feed per day. Research would suggest that the incidence of subclinical rhabdomyolysis is low in Thoroughbreds being fed a moderate caloric diet (21 Mcal/d), whether it be in the form of sweet feed or rice bran. However, when calories are increased by the addition of more sweet feed, the incidence of subclinical rhabdomyolysis is much greater. In horses with RER, one way to lower serum CK after exercise when a high caloric intake is required is to feed a low-starch/high-fat ration such as Re-leve, which contains 13% fat by weight (as rice bran and corn oil), 20% DE as fat, and 9% DE as starch. Fat supplementation without complete elimination of starch-containing feeds is appropriate for horses with RER. This type of high-energy diet can also be provided through a combination of grains (no more than 5 lb sweet feed/day) and fats such as vegetable oil (up to 600 ml/d), rice bran (up to 5 lb/d), or other commercially available fat supplements, and highly fermentable fiber sources (soy hulls, beet pulp).

There is some evidence to suggest that detrimental effects may occur when feeding a very high dietary fat intake (25–30% of daily DE). Feeding unnecessarily high dietary fat may induce loose masure, decreased digestibility of other dietary components due to depression of activity by cellulolytic bacteria, decreased dry matter intake (which may propagate electrolyte and mineral deficiencies), and obesity. Although variable results have been obtained in digestion trials due to the wide range of types and amounts of fat and fiber fed, there may be a trend for diets with greater than 15% fat to depress digestibility of NDF. It has also been suggested that high levels of dietary fat may decrease muscle glycogen concentrations, which may be detrimental to racing performance. Feeding 20% DE as fat for 3 wk to RER horses did not decrease muscle glycogen concentrations. Feeding 6–10% DE as fat to PSSM horses for 3 wk did decrease their excessively high muscle glycogen levels (3-fold normal), but they remained above the normal range.

8. Expectations of Fat Supplementation

The time required for improvement in signs of exertional rhabdomyolysis is controversial. It has been suggested that a minimum of four months of supplementation is required and that relapses are associated primarily with disruption of supplementation. However, in the authors’ experience clinical improvement with PSSM is more dependent on the amount of daily exercise and turnout than on the length or amount of dietary fat supplementation. For example, when serum CK was monitored daily post-exercise, serum CK activity was almost within the normal range after 4 wk of daily exercise, without fat supplementation. In addition, when PSSM horses were turned out 24 h/d on grass, post-exercise serum CK was normal compared to high activities during the same exercise test when stall confined on a hay diet. Thus it seems that consistent fat supplementation without implementing a structured daily exercise regime in PSSM horses is highly likely to result in failure, and confinement while consuming high levels of fat is likely to lead to obesity.

Most surprising are our recent findings in RER horses that showed significant reduction or normalization of post-exercise serum CK activity occurs within 1 wk of commencing a diet providing 20% DE as fat, and 9% DE as starch. This low serum CK activity compared to the high CK activity observed in the same horses on an isocaloric diet where 40% DE was starch was not the result of any measurable change in muscle glycogen or metabolism during exercise. Potentially, the rapid response to decreasing starch and increasing fat was a result of neurohormonal changes that resulted in a calmer demeanor, lower pre-exercise heart rates, and a de-
creased incidence of stress-induced rhabdomyolysis. Avoiding prolonged box-stall rest in fit Thoroughbreds with RER is also important, as we found that whether consuming a high-starch or high-fat diet serum CK activity was higher post-exercise following 2 d of rest compared to values taken later in the week when performing consecutive days of the same amount of sub-maximal exercise. It is quite possible that exercise exerts beneficial effects on horses with chronic exertional rhabdomyolysis that are separate from the impact of reduction in dietary starch and/or fat supplementation. Failure to implement an appropriate exercise routine is very likely to lead to failure to control rhabdomyolysis.

9. Additional Management Strategies

Daily exercise appears to be a vital adjunct for successful dietary control of PSSM. Severe affected horses may only be able to manage a few minutes of exercise a day, but with gradually increasing intervals of walk and 2 min of trot (but no more than 2 min/d), many of these horses are capable of eventually accomplishing intense daily exercise without clinical rhabdomyolysis. Stall confinement should be kept to a maximum of 12 h/d, and pasture turnout is ideal.

RER horses are often very fit when developing rhabdomyolysis and require only a few days off before commencing a reduced amount of training. Stall confinement should be kept to less than 24 h if possible. Because RER appears to be a stress-related disorder, management strategies to reduce stress and excitability in these horses are important. These include turnout, exercising or feeding these horses first before other horses, providing compatible equine company, and judicious use of low-dose tranquilizers during training. Anecdotal reports of increased nervousness have been received when selenium is supplemented at higher than the recommended levels. Feeds designed for RER, such as Re-levé, contain adequate selenium concentrations and should not be supplemented beyond that provided in the feed.

All supplemental feeds should be reduced in amount on days when energy requirements are not as high, particularly if the horse is at risk of weight gain. Other management strategies may help to decrease the intensity of the postprandial glycemic response, and include feeding small meals, providing at least 1.5% bwt/d in forage, and feeding a forage source either 2 h before or concurrently with any grain. Avoiding high-starch supplements such as molasses is also important.

In conclusion, lowering dietary starch and increasing dietary fat is an adjunct to successful management of two forms of equine exertional rhabdomyolysis. Unfit Quarter Horses with PSSM respond favorably to incremental increases in daily exercise and a moderate caloric intake composed of hay and a fat supplement, with removal of high-starch concentrates. Fit horses with RER often require a high caloric intake, which is best provided by reduction, but not elimination, of dietary starch, and a high degree of fat supplementation that can be provided in specially formulated high-fat rations.

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References and Footnotes


*Re-leve by Hallway Feeds, Lexington, KY. Re-leve is licensed by the University of Minnesota and sold by Hallway feeds. The University of Minnesota has a marketing agreement with Kentucky Equine Research that supplies the rice bran component of this diet. A portion of the proceeds of the sale of rice bran used in Re-leve go to the University of Minnesota and to Dr. Valberg.