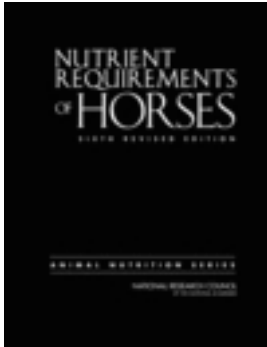


## Free Summary

### Nutrient Requirements of Horses: Sixth Revised Edition



Committee on Nutrient Requirements of Horses,  
National Research Council

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*Proper formulation of diets for horses depends on adequate knowledge of their nutrient requirements. These requirements depend on the breed and age of the horse and whether it is exercising, pregnant, or lactating.*

*A great deal of new information has been accumulated since the publication 17 years ago of the last edition of Nutrient Requirements of Horses. This new edition features a detailed review of scientific literature, summarizing all the latest information, and provides a new set of requirements based on revised data. Also included is updated information on the composition of feeds, feed additives, and other compounds routinely fed to horses. The effects of physiological factors, such as exercise, and environmental factors, such as temperature and humidity, are covered, as well. Nutrient Requirements of Horses also contains information on several nutritional and metabolic diseases that horses often have. Designed primarily as a reference, both practical and technical, Nutrient Requirements of Horses is intended to ensure that the diets of horses and other equids contain adequate amounts of nutrients and that the intakes of certain nutrients are not so excessive that they inhibit performance or impair health. This book is primarily intended for animal nutritionists, veterinarians, and other scientists; however, individual horse owners and managers will also find some of this material useful. Professors who teach graduate courses in animal nutrition will find Nutrient Requirements of Horses beneficial as a textbook.*

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## Summary

The National Research Council has published five previous editions of *Nutrient Requirements of Horses*. A great deal of research on the nutrition and feeding of horses has been conducted since the fifth edition was published in 1989. The Sixth Revised Edition contains updated information on the nutrient requirements of domestic horses and ponies, as well as expanded information on general considerations for equine feeding management. This report includes a discussion of feeding management of other equids, such as donkeys and wild equids kept in captivity. One chapter provides information on the feeding management of horses with nutritionally related disorders. A new web-based computer program has been developed that will assist users in determining the nutrient requirements of domestic horses and ponies of specific physiological classes.

In 2005, the American Horse Council estimated that the number of horses in the United States exceeded 9 million and that more than 2 million people were involved in horse ownership. The economic impact of the U.S. horse industry was estimated to be more than \$100 billion. Horses are used for recreational purposes, sport (e.g., racing, polo, and Olympic events), exhibition, breeding, ranch and farm work, and even therapy. Type of use, age, and physiological state affect the nutrient requirements of horses. Horses are distributed broadly across the United States and the world, where they are subjected to a variety of climates and housing conditions. Effective feeding management practices must consider many factors, including nutrient requirements, environmental conditions, and available feeds. This report addresses not only the nutrient requirements of horses, but also provides information on feeds, feed processing, and feeding behavior of horses. It is expected that professional nutritionists, veterinarians, feed manufacturers, researchers, teachers, students, and horse owners will use the information.

Energy systems and energy requirements of horses are discussed in Chapter 1. The energy needs of horses for maintenance, reproduction, lactation, growth, and exercise are expressed in units of digestible energy. Maintenance re-

quirements have been related to body weight, and guidelines for adjusting the energy intake to meet the needs of adult horses with various levels of voluntary activity are given. A method that enables users to estimate expected body weight of growing horses at any age from expected mature body weight has been proposed. The effect of exercise on energy requirements is discussed in this chapter, as are the effects of excessive and deficient energy intakes on horses.

Chapters 2 (Carbohydrates) and 3 (Fats and Fatty Acids) address the main energy-containing compounds used by horses. These chapters include information on the metabolism of carbohydrates and fats during exercise. Chapter 2 discusses the classification of carbohydrates in horse feeds, and Chapter 3 provides extensive review of the effects of feeding fat-supplemented diets to horses.

A comprehensive review of protein and amino acid nutrition of horses is presented in Chapter 4. Protein requirements are expressed in grams of crude protein, and lysine requirements are estimated. This chapter includes a discussion of protein digestibility and protein quality.

The requirements of horses for macrominerals and microminerals are found in Chapter 5. There has been a substantial amount of research on the mineral nutrition of horses since the previous edition of this document was published in 1989. This chapter includes an expanded discussion on several topics in mineral nutrition, including the effect of exercise on mineral requirements, and the addition of chromium and silicon to equine diets.

Chapter 6 addresses the vitamin requirements of horses. A review of the literature revealed that previous recommendations for several vitamins were based on extremely limited data. There have been a few new studies on vitamin nutrition in horses since 1989, and these studies were used to evaluate previous vitamin requirements. However, the committee relied on previous recommendations as a basis for the current estimates of requirements for several vitamins.

The section of the publication dealing with water requirements of horses has been significantly expanded.

Chapter 7 discusses water requirements, factors affecting water requirements, and water quality.

Feeds and feed processing are covered in Chapter 8. This chapter includes an extensive discussion of forages and the factors affecting forage composition. Grains, byproduct feeds, protein supplements, vitamin supplements, and mineral supplements are also discussed. The effect of feed processing on nutrient digestibility and site of nutrient absorption is also reviewed. Chapter 9 describes feed additives that affect feed characteristics (such as colors, antioxidants, flavors, and pellet-binders), as well as additives that are intended to affect animal health.

The implementation of a successful feeding program depends on an accurate assessment of the nutritional value of the feed, as well as an understanding of the nutrient requirements of an animal. Therefore, Chapter 10 addresses feed analysis. This chapter reviews many of the analytical procedures currently available for feed analysis, with particular emphasis on carbohydrates and proteins. Chapter 10 includes a schematic that compares several systems used to classify carbohydrates in animal nutrition.

Chapter 11 reviews the existing literature pertaining to feeding behavior in horses and also provides guidelines for general considerations relating to feeding management. Included in this chapter is a discussion of factors affecting vol-

untary feed intake. This chapter also addresses the relationship between dietary management of horses and the excretion of nutrients into the environment. Chapter 12 covers several unique aspects of equine nutrition, such as feeding the orphan foal and feeding horses in very hot or very cold weather. Chapter 12 also addresses the interactions between feeding management and several disorders such as colic, laminitis, recurrent airway obstruction, polysaccharide storage myopathy, and gastric ulcer syndrome. The interaction between nutrition and developmental orthopedic disease is also discussed. A new addition to this publication is Chapter 13, which summarizes the existing information related to the feeding management of wild equids in captivity as well as donkeys.

The sixth revised edition of *Nutrient Requirements of Horses* concludes with Chapters 14 and 15, which cover ration formulation and the equations used to develop the computer program that accompanies this document. In addition, the document contains sample tables that list the nutrient requirements of selected types of horses, feed composition tables, and a table summarizing the composition of mare's milk. Users should recognize that many recommendations for ponies and draft horses have been extrapolated from data obtained using light horses. Therefore, it is suggested that the recommendations for ponies and draft horses be applied with discretion.

# NUTRIENT REQUIREMENTS OF HORSES

SIXTH REVISED EDITION

Committee on Nutrient Requirements of Horses

Board on Agriculture and Natural Resources

Division on Earth and Life Studies

NATIONAL RESEARCH COUNCIL  
*OF THE NATIONAL ACADEMIES*

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## Preface

The domesticated members of the genus *Equus* (horses, ponies, donkeys, mules) are used for many purposes including competition, recreation, entertainment, transportation, farm and ranch work, and even therapy. Several nondomesticated species of *Equus* are maintained in zoological parks or are the focus of conservation efforts. The demand for information relating to the nutrition and feeding management of horses, ponies, and their relatives has grown with the popularity of these animals and with the increased interest in nutrition in general.

The Sixth Revised Edition of the Nutrient Requirements of Horses is a project of the Board on Agriculture and Natural Resources of the National Academies. This document was produced from the work of a committee appointed in February 2004. The committee accepted input from stakeholders and sponsors during several public information sessions and from a public website. The purpose of this publication is to review the existing scientific literature relating to the nutrition and feeding of horses and to summarize the information relating to nutrient requirements of horses of various physiological classes. The publication is accompanied by a web-based computer program. The computer program will calculate nutrient requirements of domestic horses and ponies of specific weights and physiological classes. Included in this edition of this publication is a discussion of the nutrition and feeding of donkeys, mules, and captive equids.

A complete review of information pertaining to the digestive physiology of the horse was outside of the charge given to this committee for this report. However, an understanding of the anatomy and physiology of the equine digestive tract will be helpful in interpreting and applying many of the recommendations contained in this publication. Reviews of various aspects of equine digestive physiology may be found in veterinary and animal science texts cited in this publication.

A great deal of new information has appeared in the scientific literature on topics related to the nutrition and feed-

ing of horses since the publication of the previous edition in 1989. New information, previously existing information, and previous recommendations have been considered in the process of determining requirements. In some cases, authors of papers on specific subjects were contacted for clarification. In addition a few data sets were obtained for some areas (growth) to augment existing values. In most cases these data sets were from a graduate thesis so were published in some format. Some areas of equine nutrition have received little study from the scientific community. Therefore, data from other animals were reviewed for applicability when studies using horses were not available. Most recent research has used horses of light horse breeding (such as Thoroughbreds, Quarter horses, Standardbreds, and Arabians). Several older studies used ponies. Very little recent information is available for draft breeds, and, similarly, few studies have compared draft breeds, light horse breeds, and pony breeds. Users should recognize that many recommendations for ponies and draft horses have been extrapolated from data obtained using light horses. Therefore, it is suggested that the recommendations for ponies and draft horses be applied with discretion. Several sections of the text provide information on how body size might affect requirements for specific nutrients.

A central purpose of this publication was to evaluate the recommendations in the previous edition in light of new information about the nutrient requirements of horses and to revise nutrient requirements when appropriate. Several mathematical equations have been derived to provide more dynamic estimates of requirements for some physiological states including growth, gestation, and exercise. The requirements shown in the tables provide recommendations for broad classifications of horses, whereas the computer program allows some flexibility in calculating the nutrient requirements for a specific animal. The values listed in this document represent the committee's best estimates of the nutrient requirements of horses of different physiological states. The required amounts of many nutrients have been

determined using average values for nutrient availability in common horse feeds. Users of the document and the associated computer program may choose to recalculate requirements when they possess specific information on nutrient availability for the rations being fed in practice. The committee recognizes that the values suggested here may not meet the need for all horses in all situations and that adjustments may be needed for individual horses or to meet specific production goals. Users of this document will find a more detailed review of the literature on equine nutrition than in previous editions. The committee has attempted to summarize information on the factors that might modify a re-

quirement, such as individual variation, breed, feed composition, and environment. It is not possible for the committee to predict every combination of variables that could influence the nutrient requirements of a specific animal. Therefore, it is incumbent upon the user to accurately assess the factors that could alter requirements and then apply appropriate adjustments accordingly.

Laurie M. Lawrence  
Chair, Committee on Nutrient  
Requirements of Horses

## Acknowledgments

This report has been reviewed in draft form by persons chosen for their diverse perspectives and technical expertise in accordance with procedures approved by the National Research Council's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards of objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following for their review of this report:

Joseph J. Bertone, Western University of Health Sciences, Pomona, CA  
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Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked

to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by R. L. Baldwin, Jr., University of California, Davis. Appointed by the National Research Council, he was responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the author committee and the institution.

The committee on Nutrient Requirements of Horses would like to express deep appreciation to all of the sponsors that contributed the funds to support this effort. Sponsors for the Sixth Revised Edition of the Nutrient Requirements of Horses included the American Feed Industry Association ([www.afia.org](http://www.afia.org)), American Paint Horse Association ([www.apha.com](http://www.apha.com)), American Quarter Horse Association ([www.aqha.com](http://www.aqha.com)), Equine Science Society ([www.enps.org](http://www.enps.org)), general support of The Animal Nutrition Series provided by the Department of Health and Human Services (U.S. Food and Drug Administration) under Award No. 223-01-01-2460 ([www.fda.gov/cvm/](http://www.fda.gov/cvm/)), and North American Equine Ranching Information Council ([www.naeric.org](http://www.naeric.org)). The funding for this project was necessary to support the travel and communications costs of the committee during the course of its work, as well as the work of the National Research Council staff who organized meetings, maintained the website, and compiled the draft and final documents.

The committee would also like to thank all of the individuals who helped to make this project a reality. Charlotte Kirk Baer, former Board on Agriculture and Natural Resources (BANR) director, was instrumental in developing the original proposal that received approval from the Board on Agriculture and Natural Resources in August of 2003. Ms. Baer was also integrally involved in developing the funding for this project, as were Dr. Donald Topliff, West Texas A&M University, and Dr. Randy Robbins, chairman

of the American Feed Industry Association (AFIA) Specialty Committee. Austin Lewis was a tireless manager as the program officer assigned to this committee. The committee sincerely appreciates the wealth of experience and perpetual optimism that Dr. Lewis brought to this project. The work of this committee could not have been completed without the able assistance of Donna Jameison, senior program assistant and Ruthie Arieti, project assistant. Finally, we would like to thank Robin Schoen, who replaced Ms. Baer as BANR director in 2004.

In the process of planning, researching, and writing this document, the committee obtained input and advice from several sources. We would like to thank Kentucky Equine Research, Inc. and the American Society of Animal Science for allowing us to present public information sessions at their

annual meetings in 2004. The committee also thanks Dr. Mary Beth Hall and Dr. George Fahey, who provided advice on topics related to carbohydrate classification and analysis. We would also like to thank the American Feed Industry Association for providing input at an open session of the initial meeting of our committee. The committee is indebted to Michael Barry, who compiled the computer program that accompanies this report and provided invaluable advice to the committee. Finally the committee would like to thank their families, students, colleagues, and home institutions. Without their patience and willingness to accept additional responsibilities, this project would not have been accomplished. This list of acknowledgements would not be complete without the recognition of the work of previous committees. We hope that our efforts will do justice to the tradition of excellence established by those who came before us.

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