Re-defining Mineral Nutrition

CONTEXT

Context Products Ltd
53 Mill Street, Packington
Leicestershire, LE65 1WN, United Kingdom

www.contextproducts.co.uk

First published 2005
Reprinted (digitally) 2013

British Library Cataloguing in Publication Data
Redefining Mineral Nutrition
I. Waldron, L.A., II. Taylor-Pickard, J.A.

ISBN 978-1-899043-58-3

Disclaimer

Every reasonable effort has been made to ensure that the material in this book is true, correct, complete and appropriate at the time of writing. Nevertheless, the publishers and authors do not accept responsibility for any omission or error, or for any injury, damage, loss or financial consequences arising from the use of the book.

CONTENTS

Introduction

The field of mineral nutrition is one that has received scant attention from researchers since the 1970's. Data generated during the last decade has been indirect, via the development and understanding of phytase enzymes for example. Since the mid 1990's there has been increasing concern regarding pollution from intensive farming, particularly in densely polluted countries in, for example, Northern Europe or areas where geological conditions increase the potential for ground water contamination. Such concerns have forced animal producers to look at how they affect pollution. This began with changes in phosphorous and nitrogen delivery and is now expanding into other micronutrients and trace elements such as zinc and copper.

Analysis of the available literature shows that basic inorganic requirements for farm animals were devised, in some cases, half a century ago. The animals used then were of a completely different genetic character, with low growth potential, reared under radically different welfare and management systems, and fed diets that bear little resemblance to those used today. The low cost of inorganic minerals used in premixes and complete diets has resulted in limited investment into trace element research. With these points in mind, it seems that the feed industry is ill-prepared to make important changes to the way minerals are supplied to breeding and growing animals, allowing pollution targets to be met. It is therefore timely that the current state of mineral nutrition of farmed species is examined in closer detail, and put into commercial context. It is also necessary to identify and compare innovations in mineral supply via feed, to minimise excretion without compromising performance.

To give nutritionists, veterinarians and producers a concise and focussed review of the current and future state of mineral nutrition in farmed species, seminars hosted by Alltech, were run covering poultry, pigs and ruminants in October 2004. The key objectives of the seminars were to examine how and why minerals are fed, commercial requirements and constraints for in-feed minerals, the increasing regulations governing current and future disposal of excreted minerals, and new approaches to supplying minerals in lower dosed, more natural and less wasteful forms. This latter point gave rise to the concept of "*redefining mineral nutrition*".

To have such a complete coverage of a topic available is of great value to modern-day nutritionists and veterinarians. The opportunity to devote a single day at a dedicated species seminar is a highly useful and efficient way of reviewing existing information, and transferring novel concepts regarding these subjects, and enables informed decisions to be made regarding key issues such as improving performance or limiting pollution.

As part of an expanding series of specialist nutrition-focussed seminars, sponsored by Alltech, the topics covered have generated great interest amongst the many delegates from a spectrum of animal health and production operations from different parts of the world. We trust that readers of the papers will also find them as stimulating.

Dr Julie Taylor-Pickard
Dr Lucy Waldron
December 2004

Setting the NRC standards for minerals – were we right?

Gary L. Cromwell[1] and Charlotte Kirk Baer[2]
[1]Department of Animal Sciences, University of Kentucky, Lexington, KY 40546, USA; [2]Board on Agriculture and Natural Resources, National Academy of Science, National Research Council, Suite 686 500 Fifth Street NW, Washington, DC 20001, USA

Energy and essential nutrients such as amino acids, minerals, and vitamins are required by animals for the various processes of life, including maintenance, growth, reproduction, lactation, and work. Having accurate estimates of dietary nutrient requirements of animals is important. Deficiencies of even a single nutrient in a diet will limit an animal's performance and well-being, and diets with excessive nutrients are expensive and contribute to environmental pollution.

The National Research Council (NRC) plays an important role in establishing nutrient requirements for animals. Whether the nutrient requirements are accurate or not is often a subject of debate among nutritionists in academia and the feed industry. Before addressing the question of whether the nutrient requirement standards are, or are not, accurate, let's review what the NRC is and how this body goes about establishing nutrient requirements of animals raised to produce food and fiber and for work and recreation.

Background of the National Research Council

Contrary to what some people believe, the NRC is not part of the federal government. Instead, the NRC is a private, nonprofit organization with a long history. The NRC was established in 1916 to provide advice to the U.S. Federal Government on issues of science and technology. The NRC is the "working arm" of The National Academies, which includes the National Academy of Sciences (NAS), an honorary society instituted 141 years ago (in 1863) by President Abraham Lincoln through an act of Congress. Members are elected to the Academy based on their contributions to science. The NRC has ten major units, one of which is the Board on Agriculture and Natural Resources (BANR). The Committee on Animal Nutrition (CAN) has been the longest standing committee of the BANR and the NRC. Dating back to the establishment of the NRC itself, CAN has addressed issues of animal feeding since 1917. It's series of publications on nutrient requirements, written by

subcommittees and overseen by CAN, covers nearly 30 species of food, companion, and laboratory animals. These reports have been translated into seven languages and are used worldwide. Reviews of the history of CAN and the NRC were recently published (CAN, 1998; Ullrey, 2001).[1]

The first of the nutrient requirement publications, *Recommended Nutrient Allowances for Swine* and *Recommended Nutrient Allowances for Poultry* were published in 1944 (NRC, 1944a; b). These were concise documents (the swine publication was 10 pages) that identified the nutrients known at that time to be essential for pigs and poultry and that listed dietary requirements for some of these nutrients. The following year, similar publications were released for beef cattle, dairy cattle, and sheep (NCR, 1945a; b; c). The first publication of this type for horses was published four years later (NRC, 1949).

In 1953, the titles of the NRC publications were changed from "Recommended Nutrient Allowances" to "Nutrient Requirements." This was a major philosophical change in how nutrient standards were established by NRC. Prior to 1953, recommended allowances included subjectively established safety factors and were intended to ensure that minimal nutrient requirements would be met under any circumstances. In some cases, recommended allowances were based on practical experience. Since 1953, NRC requirements have been considered as the minimal dietary concentration of a nutrient required to support normal performance for the most demanding function.

Process of producing the NRC's nutrient requirement publications

The process by which nutrient requirement publications are prepared is relatively simple, but it is thorough, rigorous, and somewhat time-consuming. Once the study proposal has been approved, and an understanding exists between the sponsor and BANR, the study may commence. Studies may have one or several sponsors from government or the private sector, or both. Because the NRC offers a one-of-a-kind service, not duplicated by other organizations, it does not compete for federal contracts. The NRC provides a public

[1] The Committee on Animal Nutrition was dissolved at the end of 2003 due to inadequate support to maintain it as a standing activity of the National Academies. To improve efficiency of the animal nutrition operating program and to address needs for operating support, the program has been restructured and the responsibilities of CAN, including the nutrient requirement series, have been assumed by the Board on Agriculture and Natural Resources.

service, which is supported by the users of its products. In the case of nutrient requirement publications, the reports are produced by the non-profit NRC and are published and disseminated throughout the world by the non-profit National Academy Press. It is through the dedicated work of volunteer experts and the financial support of end-users that the reports are made widely available for use in the industry, government, research, and teaching communities.

Staff with input and oversight from the relevant boards initiates the search for candidates for subcommittee membership. In defining the areas of expertise that should be represented on a subcommittee and identifying individuals qualified to serve, the staff reviews scholarly literature and consults widely with members of the National Academies, BANR, knowledgeable authorities, and professional associations. Sponsors may offer suggestions but are not responsible for selecting subcommittee members. Subcommittee members are chosen on the basis of their experience in the various areas of nutrition, and after careful review by BANR, they are appointed by the chair of the NRC, who also is president of the NAS. Subcommittee members serve as individuals, not as representatives of organizations or interest groups. Members are sought with background and experience in academia, government, and industry. Each person is selected on the basis of his or her expertise and good judgment, and is expected to contribute accordingly to the study. Potential sources of bias and conflict of interest are significant issues that are taken into consideration in the selection of subcommittee members.

A successful report is the result of a dynamic group process, requiring that subcommittee members be open to new ideas and innovative solutions, and be willing to learn from one another and from other individuals who provide input. Subcommittees are expected to be even-handed and to examine all evidence dispassionately. The subcommittees review the world's literature, particularly research published since the last edition. Although all interested parties should be heard and their views given serious consideration, one of the subcommittee's primary roles is to separate fact from opinion, and analysis from advocacy. Scientific standards are essential in evaluating all arguments and alternatives. Experience suggests that completing the consensus process and writing a report that clearly represents the subcommittee's findings is the most difficult, frustrating, yet rewarding aspect of serving on a study subcommittee. Many audiences such as regulatory, research, and industry, to name a few, use the report. For this reason, the report must be of the highest quality. Although each subcommittee may approach the drafting of its report differently, every report is the collective product of a group process.

Like all good science, reports should be based on fact and rigorous analysis. All reports must undergo an independent review by anonymous expert panels of reviewers. Review is a multi-tiered process, which ensures the highest level of quality that sets the NRC apart from any other organization. While the report is reviewed by expert scientists, a review coordinator and monitor, as well as the NRC's report review subcommittee oversee the entire process.

Upon completion of the report, the National Academy Press publishes it. The Press prints and sells the report at cost, and strives to make the report widely available to users on a global scale.

Setting requirements for swine

The process for establishing nutrient requirements is similar for the various species of animals; however, this paper will specifically address the process of setting the requirements in the most recent edition of *Nutrient Requirements of Swine* (1998). The swine subcommittee was appointed in 1994 and consisted of the following members:

Dr. David H. Baker, University of Illinois
Dr. Richard C. Ewan, Iowa State University
Dr. E. T. Kornegay, Virginia Polytechnic Institute and State University
Dr. Austin J. Lewis, University of Nebraska
Dr. James E. Pettigrew, Pettigrew Consulting International, University of Illinois
Dr. Norman C. Steele, U.S. Department of Agriculture – Agricultural Research Service
Dr. Philip A. Thacker, University of Saskatchewan
Dr. Gary L. Cromwell, University of Kentucky (Chair)

The subcommittee initially met in 1994 and was given their charge by the Program Director of CAN, Charlotte Kirk Baer. The initial meeting included the chair of the Nutrition Council Swine Committee of the American Feed Industry Association, Dr. Kevin Halpin. He provided suggestions from nutritionists at feed companies and ingredient suppliers who were involved in servicing the swine feed industry that assisted the subcommittee in setting goals and establishing direction for the revised publication. He indicated that nutritionists from the feed industry were willing to provide data on feed composition and nutrient requirement studies if requested by the subcommittee.

At their initial meeting, the subcommittee decided to use a modelling approach to assist in establishing nutrient requirements. Realizing

model uses a default curve (Figure 1) to make this calculation. The shape assumes that daily protein accretion rate accelerates during early growth, reaches a plateau, then the rate declines during the finishing period. Pigs with different lean growth rates have the same general pattern of protein accretion but the heights of the curves will differ (Figure 2). The software allows the user to input different shaped curves, if desired.

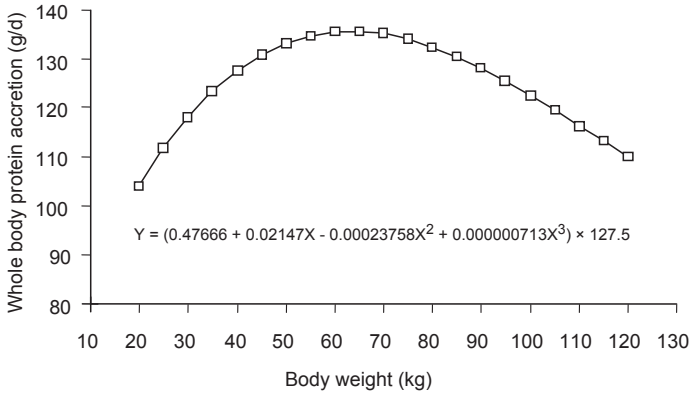

Figure 1. Potential whole-body protein accretion rate of pigs of high-medium lean growth rate with a carcass fat-free lean gain averaging 325 g/day from 20 to 120 kg of body weight using the NRC (1998) growth model. The lean growth rate of 325 g/day is converted to a mean whole-body protein accretion rate of 127.5 g/day (325/2.55 = 127.5).

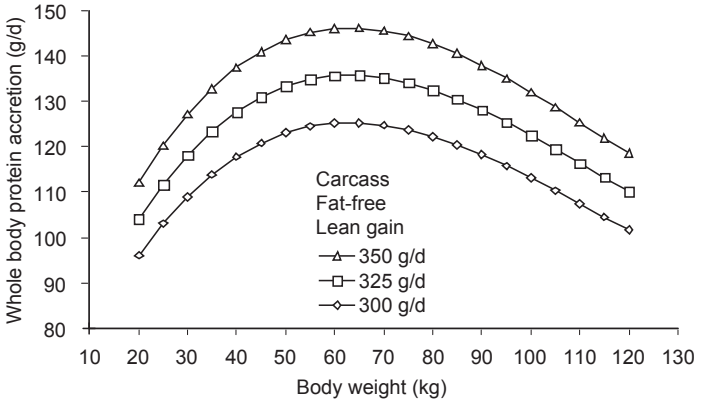

Figure 2. Whole-body protein accretion rates of pigs of medium, high-medium, and high lean growth rates with carcass fat- free lean gains averaging 300, 325, and 350 g/day from 20 to 120 kg of body weight as estimated by the NRC (1998) growth model.