猪蛋白质营养

Swine Protein Nutrition

郭荣富 戴志明 张曦 王志祥 主编

云南省科技厅应用基础研究重点基金资助项目

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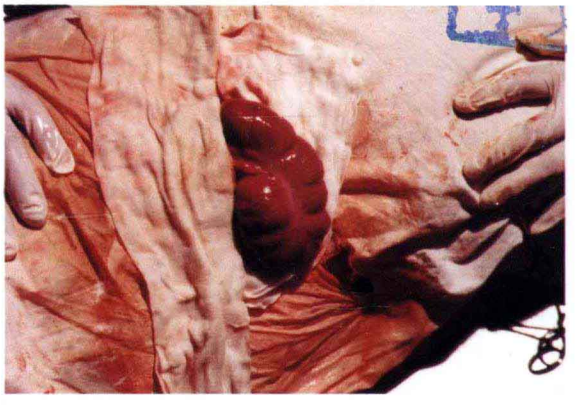

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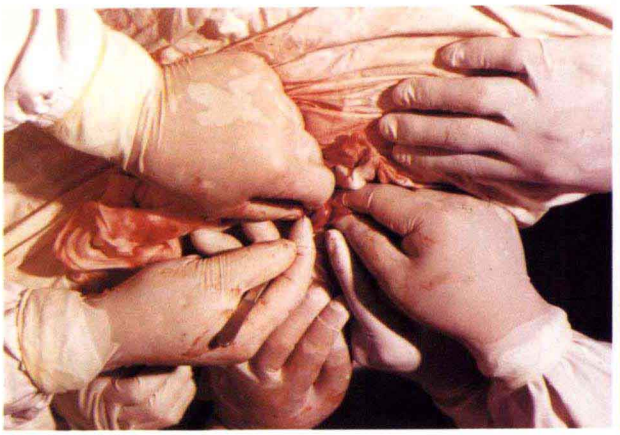

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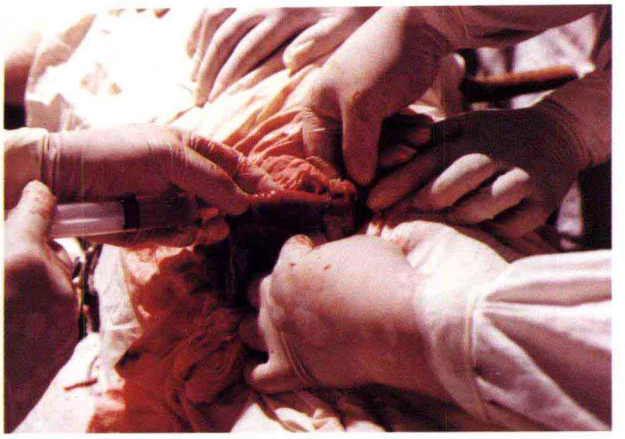

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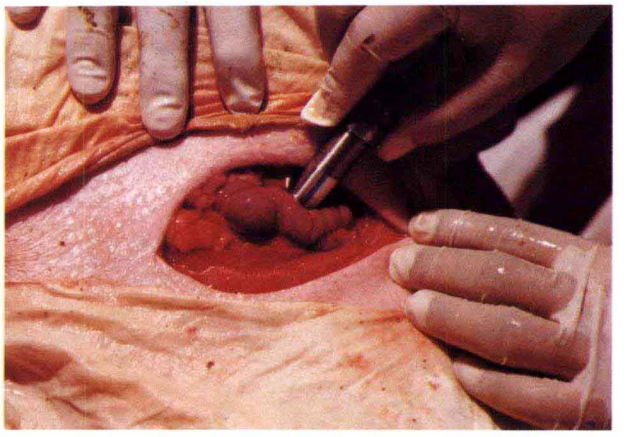

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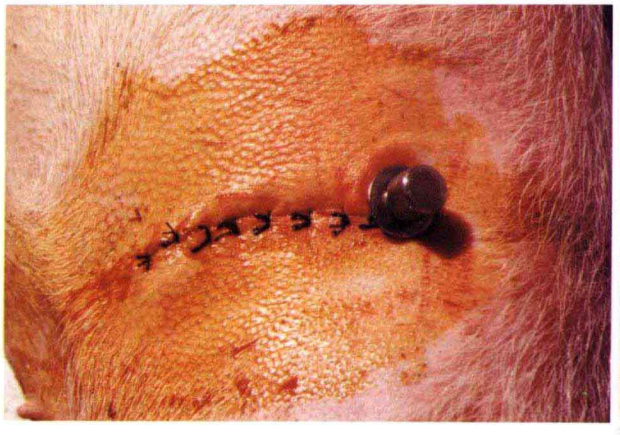

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序

蛋白质既是生命的存在形式，也是生命活动的物质基础。长期以来，对蛋白质的研究一直是生命科学的重点和热点领域，是认识生命和控制生命的关键环节。近十几年来，随着生物化学和分子生物学的迅速发展，对蛋白质的研究无论是研究内容和研究手段，还是在研究成果及其对人类生活的贡献方面，都取得了惊人的成就。动物营养学作为生命科学的分支学科，其核心组成部分无疑也是蛋白质营养。同时，自然界中蛋白质资源十分匮乏，动物对蛋白质转化总效率很低。动物营养学作为应用基础学科，其核心任务就是在消化吸收基础学科，在蛋白质代谢研究成果的基础上，研究提高动物蛋白质利用效率的营养理论和饲养技术，以提高动物蛋白的生产效率，满足人类对动物蛋白需求量不断增加的需要。由此可见，蛋白质营养在动物营养学中的地位和作用十分显要。

近几年来，随着基础学科的发展，动物营养学的整体水平也有了明显提高。在猪的蛋白质营养方面，最明显的进展是从粗蛋白营养向氨基酸营养的不断深入。氨基酸平衡理论，理想氨基酸模式，可利用氨基酸及其评定技术，氨基酸营养需要动态模型等新概念、新方法的提出或建立使氨基酸营养原理逐步深入和完善。与此同时，肽的营养、蛋白质与免疫、蛋白质氨基酸与基因表达、蛋白质与猪肉品质等新兴领域的研究正在蓬勃开展，分子生物学、生物数学、计算机、核科学等相关学科对蛋白质营养研究的渗透也不断深入。由于研究手段的改进，蛋白质周转代谢又成为近几年的研究热点，将为准确评定蛋白质氨基酸需要量积累更多参数。系统总结上述研究成果，对于学习和研究动物蛋白质营养十分必要。

与国际先进水平相比，我国动物营养学，尤其在蛋白质营养方面的差距比较明显。云南省动物营养与饲料重点实验室近几年在猪的蛋白质营养方面开展了系统研究，取得了新的进展。《猪蛋白质营养》一书即融贯了这些进展和国内外的研究成果，反映了该领域的最新成就。该书内容丰富、资料新颖、文笔流畅，具有较高的学术价值。该书的出版，不仅代表了课题组的研究成果，而且有利于促进我国蛋白质营养学的教学、科研和应用的发展，缩短与国际水平的差距，是我国动物营养界值得庆贺的大事。

蛋白质营养是动物营养学的重要领域，也是难点领域，很多问题有待深入研究。希望广大科技人员在学习《猪蛋白质营养》的基础上，认真思考和研究该领域存在的问题，加强学术交流，推动我国蛋白质营养的发展。

四川农业大学　杨　凤
2002 春，于雨城

PREFACE

Protein is not only the existing form of life, but also the material basis of life activity. Research on protein is always emphasis and hotspot area of life sciences for a long time, and is the key procedure of recognizing and dominating life. Since 1990, with the rapid development of biochemistry and molecular biology, research on protein acquired prodigious achievements not only in the contents and methods of research, but also in the achievements and contributions of it to human. As an important branch of life sciences, the kernel of animal nutrition is protein nutrition. At the same time, protein resources are highly scarce in nature, and the total efficiency of protein transformation by animal is very low. Based on applied research achievements of digesting and absorbing basic subjects on protein metabolism, as an applied basic subject, the kernel of animal nutrition is to research nutritional theory and breeding techniques of enhancing protein utilization, increasing animal productivity and satisfying human requirements for animal protein. Therefore, it can be shown that animal nutrition is very important on the status and actions of protein

In the recent years, with the development of basic subjects, the animal nutrition has totally advanced distinctly. In the protein nutrition of swine, the distinct advancement is the incessant advancement from crude protein nutrition to amino acid nutrition. New concepts and methods, such as amino acid balance theory, ideal amino acid pattern, available amino acids and its assessment techniques, dynamic modeling of amino acid nutritional requirements were brought forward or set up, which makes the amino acid nutritional principle penetrating and perfecting gradually. Meanwhile, some new research fields, such as peptide nutrition, protein and immunity, protein, amino acids and gene expressions, protein and pork quality are being flourishingly developed. Some related subjects, such as molecular biology, biomathematics, computer science, nuclear science, and so on, have been applied to protein nutritional research constantly. Because of the improvement of research techniques, protein turnover metabolism again becomes a new research hotspot in recent years, which will be in favor of accumulating more parameters for exactly assessing protein and amino acid requirements. It is necessary to study and research animal protein nutrition in order to summarize the above all research achievements.

Compared with developed countries, research and application of animal nutrition, especially in protein nutrition of swine, is being at the disadvantage in China. During latest years, Yunnan Animal Nutrition and Feed Laboratory carries out the systemic research on protein nutrition of swine and acquires some latest achievements. This book, "Protein nutrition of swine", introduces and reflects the recent advances and latest achievements at home and abroad in this field. This book is rich and colorful in contents, novel in the information and influent in writing, which academically have upper value. The release of this book will accelerate the teaching, research and application of protein nutrition, and shorten the differences between our country and developed countries. It is a thing that is worthwhile

congratulating in the animal nutrition field.

Protein nutrition is an important and difficult field of animal nutrition, and there are still many issues to be further researched. It is hopeful that scientists consider and study earnestly existent issues in this field, and academically communicate each other in order to promote the development of protein nutrition, based on studying this book "Protein nutrition of swine".

Professor Yang Feng
Honorary President At Sichuan Agricultural University
In April 2002. In Rainy City.

前　言

蛋白质是动物生命表现的重要物质基础，蛋白质沉积是动物蛋白质合成与蛋白质降解的动态平衡结果，蛋白质周转代谢是表现动物蛋白质动态代谢的动力学过程，也是动物生命进化表现和一种生物适应性机制，其功能性蛋白质的产生即基因表达。蛋白质代谢受基因型、营养、激素、环境等因素的调控，充分发挥动物蛋白质最大遗传生长潜力正是现代畜牧生产的主要目的。

氨基酸是构成蛋白质的基本组成单位，氨基酸与肽营养反映了猪蛋白质营养的本质，免疫激发影响蛋白质代谢与氨基酸需要，急性期蛋白质生物合成可改变氨基酸需要量，蛋白质营养与免疫是值得研究的重要领域。基于理想氨基酸模式，从动态模型出发，采用可消化氨基酸体系，可以使氨基酸的供给与猪的蛋白质需要之间达到较精确的统一。

氨基酸生物利用率是一个抽象的概念，实践中已采用回肠末端氨基酸消化率，在其评定方法中，国内外倾向于采用回—直肠吻合法。基因型、饲料中抗营养因子、饲粮抗原、加工工艺、测定方法等影响氨基酸利用率，客观地评价具有地方资源特色的饲料回肠末端氨基酸消化率是一项长期的基础研究工作，构建氨基酸消化率数据库，并采用可消化氨基酸体系无疑具有重要实践意义。

可靠的研究方法和分析测试技术可提供蛋白质代谢的有重要参考价值的试验结果，较好地反映和解释蛋白质定量转化规律。蛋白质周转代谢研究方法，分域系统的理论与方法，分子生物学技术并结合电子计算机技术的应用，无疑将提供蛋白质动态代谢和利用的重要生物信息。

母猪营养是猪营养研究和养猪生产的最重要组成部分，而这一领域的研究资料积累相对较少，特别是母猪蛋白质与氨基酸营养、蛋白质代谢动力学、母猪养分需要模型研究均具有重要价值和实践意义，但其研究难度也较大，若进一步发展和完善其研究方法及实验条件，预期未来可取得突破性进展。

由于猪与人的消化生理特点的相似性，猪被用作人类的生物研究模型，主要包括人类生物医学研究和人类营养研究的动物模型。由于长期的自然封闭，进化和生态环境的作用形成了微型猪种。微型猪体型小、易管理、试验成本低等特点，使其更具有适用性，实验动物的潜力，如遗传工程、异种器官移植、重组 DNA、胎儿氨基酸代谢、人类营养模型等的研究，要求其遗传背景一致，并且生理障碍和免疫排斥仍是异种器官移植的障碍，采用基因敲除法可能克服其障碍，而人类干细胞研究可能提供另一条途径。同时，采用猪为人类异种器官移植的供体也面临着某些动物传染病感染和道德观念的挑战。

通过营养技术调控可显著改善猪生长性能和胴体品质，现代养猪生产追求最大瘦肉量或最大蛋白质沉积。由于 β－兴奋剂等的禁用，猪生长激素、pGRF 基因质粒的应用将是新的有效调控技术。营养效应、生态效应和经济效益的整合应是现代养猪研究和生产的目标。

本书是在我们多年来对猪蛋白质代谢及饲料优化利用技术、版纳微型猪蛋白质代谢研究成果的基础上，总结国内外猪蛋白质代谢最新研究进展编写而成，具有重要参考价值。本

书由四川农业大学名誉校长、我国著名动物营养学家、博士生导师杨凤教授作序，四川农业大学动物营养学专家、博士生导师陈代文教授主审。该书由郭荣富教授统稿。本书适用于研究生、本科生、科研院所的读者参考，同时也适用于各饲料厂、养殖户等不同层次的读者参考。由于编写时间较短，如有遗漏和不妥之处，敬请同行专家和读者批评指正。书中参阅引用了国内外其他作者的有关文献资料，在此，我们表示衷心感谢。

本书编著人员如下：

第一章：戴志明、郭荣富、赵素梅；第二章：郭荣富、王志祥（河南农业大学）、陈泉、赵素梅；第三章：郭荣富、朱家瑜、肖啸、陈泉、张春勇；第四章：郭荣富、陈泉、陈克嶙、张春勇；第五章：张曦、郭荣富、陈泉；第六章：郭荣富；第七章：王志祥、郭荣富、陈泉；第八章：郭荣富；第九章：郭荣富；第十章：陈克嶙、张春勇、陈泉、郭荣富；第十一章：戴志明、张曦、安清聪、赵素梅；第十二章：戴志明、王志祥、张曦、郭荣富、赵素梅；第十三章：郭荣富；第十四章：郭荣富、陈克嶙、张曦、戴志明；第十五章：陈克嶙、张春勇、张曦、郭荣富；第十六章：张曦、陈克嶙、李青、刘勇；附录一至附录三：张曦、陶琳丽；附录四：郭荣富、陈克嶙、陶琳丽。

郭荣富　戴志明　张　曦　陈克嶙

2002 年 4 月

INTRODUCTION

Protein is important material basis of animal life. Protein accretion is the result of the dynamic balances between protein synthesis and degradation. Protein turnover is a kinetic process of protein metabolism, and is also an evolutionary expression and an adaptive mechanism of animal life. The production of functional protein is gene expression. Protein metabolism is regulated by many factors, such as genotypes, nutrition, hormone, feeding regimens, and so on. The main purpose of modern animal production is to make full use of maximum genetic growth potential of animals.

Amino acid is the basic unit of protein. Amino acid nutrition and peptide nutrition reflect the essence of swine protein nutrition. Immune activation affects animal protein metabolism and amino acid requirements. Biosynthesis of acute phase proteins can modify amino acid requirements. The relationship between protein nutrition and immunity of swine is an intriguing and worthwhile area to be researched. From point view of dynamic modeling, The supplementation with amino acids can exactly satisfy the protein requirements of swine, based on ideal protein and used the digestible amino acid system.

Amino acid bioavailability is an abstract concept. In the practice we usually use the ileal amino acid digestibilities. Of all measurements of feed amino acid digestibilities in the world, people are inclined to use ileo – rectal anastomosis technique. The amino acid availability is affected by genotypes, anti – nutrition factors, feed antigen, processing techniques, determination, and so on. The measurement of feed amino acid digestibility will be a long basic research job in order to objectively assess the ileal amino acid digestibility of local feed resources. It will be no problem to be important significance in the practice to build up amino acid digestibility database on the basis of digestible amino acid system.

The reliable research methods and analytic techniques can supply experimental results with important reference value. It will reflect and explain biological quantitative laws of protein turnover. The combination of protein turnover research methods, theory and methods of compartment system, molecular biological techniques and computer science will be definitely to give important biological information of protein kinetics and utilization.

The sow nutrition is the most important component part of swine nutrition research and production. However, little is known to the information of sow nutrition. Especially the researches about sow protein and amino acid nutrition, protein metabolism dynamics and sow nutrient requirement modeling are important and instructive in practice. At the same time it is very difficult to conduct these researches. If the research methods and experiment conditions can be further improved, we will make a breakthrough in the near future.

Due to the similarity of digestive physiology of swine and human being, swine is usually used as animal model of biological research of human being, mainly including human medical research and nu-

trition. The miniature pig has appeared due to the result of long natural closure and the influence of evolution and ecological environment. The miniature pigs have some characteristics, such as little size, easily managing, low experimental cost, and so on, which makes them having potentials being used as experimental animals, such as the researches of genetic engineering, xenotransplantation, recombinant DNA, fetus amino acid metabolism, nutrition modeling of human being. Of course the researches require the same genetic background. Physiological and immune rejections are still the obstacles of xenotransplantation. Knockout gene may overcome the above obstacles. The human being stem cell research may be another means for xenotransplantation. However, we still face some challenges, such as animal infectious disease and moral thoughts if swine is used as donors of xenotransplantation.

The nutrition modifiers can remarkably improve growth performance and the carcass quality of pork. Modern pig production pursues maximum muscle or maximum protein accretion. Because the β-agonists are prohibited, the swine growth hormone and pGRF gene plasmid will become the regulatory technique. The integrity of nutrition, ecology and profit should be the target of modern swine research and production.

We compiled this book 'Protein nutrition of swine', based on the results of these scientific projects, namely 'protein nutrition and optimal utilization techniques of feed in Yunnan swine breeds' and the 'protein metabolism of Banna miniature pigs'. This book also covers the latest research advances on protein metabolism of swine at home and abroad. This book is suitable for undergraduate and post-graduate students, the researchers of institute and university, as well as for readers of feed mill and swine industries. Owing to the shortage of time, if there is any mistake, welcome the readers to put forward your comments and suggestions. We are most grateful to these authors whose references were cited in this book.

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Guo Rongfu Dai Zhiming Zhang Xi Chen Kelin

April. 9, 2002

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