



# 反刍动物生理与营养研究

Ruminant Physiology & Nutrition Research

## 论文摘要汇编

A Corpus: Abstracts of the Theses  
( 2005—2016 )

◎ 反刍动物生理与营养实验室 编



中国农业科学技术出版社



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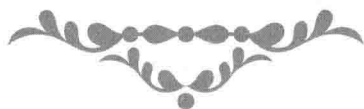
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## 图书在版编目 (CIP) 数据

反刍动物生理与营养研究论文摘要汇编 / 反刍动物生理与营养实验室编.  
—北京: 中国农业科学技术出版社, 2016. 10

ISBN 978-7-5116-2755-1

I. ①反… II. ①反… III. ①反刍动物-生理学-文集②反刍动物-动物  
营养-文集 IV. ①S823-53

中国版本图书馆 CIP 数据核字 (2016) 第 227283 号

责任编辑 张国锋

责任校对 马广洋

出版者 中国农业科学技术出版社

北京市中关村南大街 12 号 邮编: 100081

电 话 (010) 82106636 (编辑室) (010) 82109702 (发行部)

(010) 82109709 (读者服务部)

传 真 (010) 82106631

网 址 <http://www.castp.cn>

经销者 各地新华书店

印刷者 北京富泰印刷有限责任公司

开 本 787mm×1 092mm 1/16

印 张 16.5

字 数 446 千字

版 次 2016 年 10 月第 1 版 2016 年 10 月第 1 次印刷

定 价 98.00 元

# 《反刍动物生理与营养研究论文摘要汇编 (2005—2016)》

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# 前 言

中国农业科学院饲料研究所反刍动物生理与营养实验室创建于2000年。在首席专家刁其玉研究员的带领下，致力于幼龄反刍动物（后备牛、羔羊）生理营养及饲料配制技术、肉羊营养需要和饲料及添加剂、高纤维性饲料利用技术及饲料评价新方法研究。本书汇编了实验室历年来博士、硕士研究生毕业论文的摘要，以期向国内外学者介绍我们的研究历程，并真诚地希望我们共同在反刍动物生理与营养领域开展深入的研究，推动幼龄反刍动物培育科学和技术的发展。

编 者  
2016年10月

## Preface

The Laboratory of Ruminant Physiology and Nutrition (LRPN) in Feed Research Institute, Chinese Academy of Agricultural Sciences, was established in 2000 with the principal investigator of Prof. Qiyu Diao. The whole research team is dedicated to improve understanding of the physiology and nutrition of young ruminants (calf, heifer, lamb), nutrient requirement of meat sheep, innovative utilization technology of forage, feed additives, and feed evaluation systems. The research abstracts collected in this book were from PhD and MSc graduation theses in LRPN, to introduce the achievements and progress obtained in young ruminant research. We sincerely welcome you for further collaboration in ruminant physiology and nutrition, to make contribution to the young ruminant research and production industry.

The editors  
October, 2016

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# 第一篇 犊牛生理与营养研究

## Chapter 1 Physiology & Nutrition Research of Calves

### 一、蛋白质营养 Protein Nutrition

#### 蛋白质水平与来源对早期断奶犊牛消化代谢及胃肠道结构的影响

李辉 (博士, 2008 年)

本研究以早期断奶犊牛为对象, 较全面地研究了日粮蛋白质水平与来源、赖氨酸水平对犊牛生长性能、消化代谢、血清生化指标、胃肠道器官及组织形态发育的影响, 具体内容分以下 5 个部分。

##### 试验一: 断奶日龄对犊牛早期断奶效果的影响研究

选用 25 头新生荷斯坦犊牛, 随机分成 5 组, 试验组犊牛分别在出生后 6、16、26 及 36 日龄时利用代乳品断奶, 分别记为 6E、16E、26E 及 36E 组, 对照 C 组饲喂牛奶, 生长性能试验持续 70d。结果发现, 试验结束时 6E 组犊牛体重和 ADG 显著高于 C 组 ( $P < 0.05$ ), 其余 3 组与 C 组间无显著差异 ( $P > 0.05$ ); 6E、16E 组犊牛体斜长、胸围显著大于 C 组 ( $P < 0.05$ )。

##### 试验二: 蛋白质来源对犊牛消化代谢及胃肠道结构发育的影响

选用 15 头新生荷斯坦犊牛, 随机分成 3 组, 分别饲喂乳蛋白、植物性蛋白比例为 80 : 20、50 : 50 及 20 : 80 的 3 种代乳品, 记为 S20、S50 及 S80 组。在犊牛 46~55 日龄内进行消化实验, 8 周龄试验结束时禁食剖杀。结果表明, 蛋白质来源对 2~8 周龄犊牛生长性能及营养物质表观消化率无显著影响 ( $P > 0.05$ ); 日粮植物性蛋白含量增加可促进犊牛瘤网胃的发育 ( $P > 0.05$ ); 犊牛肝脏、胰脏的相对比重受蛋白质来源影响显著 ( $P < 0.05$ ); 蛋白质来源影响犊牛肠道的绒毛形态, 但不影响肠道绒毛高度与隐窝深度的比值 ( $P > 0.05$ )。

##### 试验三: 蛋白质水平对哺乳期不同阶段犊牛消化代谢的影响

选用 9 头新生荷斯坦公犊牛, 记为 LP、MP、HP 3 组, 分别饲喂等能值粗蛋白质含量为 18%、22% 及 26% 的 3 种代乳品。分别在犊牛 12~20、22~30、32~40、42~50 及 52~60 日龄内进行 5 期消化代谢实验。结果发现, 随犊牛日龄增长, 日粮 DM 的表观消化率缓慢下降; CP 和 EE 的表观消化率略有上升。日粮 DM、EE 的表观消化率随蛋白质水平升高而上升, 但 CP 的消化率以 MP 组最高。高蛋白质水平可导致犊牛血清 BUN 含量升高

( $P < 0.05$ )；MP 组犊牛血清 GLU 和 TP 含量高于其余两组 ( $P < 0.05$ )。

#### 试验四：蛋白质水平对犊牛消化代谢及胃肠道结构发育的影响

选用 15 头新生荷斯坦犊牛，随机分为 3 组，分别饲喂不同蛋白质水平的代乳品（在试验三基础上改进），仍记为 LP、MP 及 HP 组。分别在试验犊牛 4、5、6 及 7 周龄早饲前进行瘤胃导管实验，8 周龄试验结束后禁食剖杀。结果发现，3 组犊牛 6 周总增重分别达到 25.1kg、34.8kg 及 26.4kg。蛋白质水平对日粮氨基酸的表观消化率影响不显著 ( $P > 0.05$ )。22% 的蛋白质水平可促进瘤胃乳头的发育；且有利于瘤胃内挥发性脂肪酸的产生 ( $P < 0.05$ )。蛋白质水平影响犊牛的肠绒毛形态；高蛋白质水平可降低肠道的绒毛高度隐窝深度比 ( $P < 0.05$ )。

#### 试验五：赖氨酸水平对犊牛消化代谢及胃肠道结构发育的影响

选用 15 头新生荷斯坦犊牛，随机分成 3 组，分别饲喂低 (1.35%)、中 (1.80%)、高 (2.25%) 3 种赖氨酸水平的代乳品，记为 LY、CY 及 HY 组。在犊牛 48~55 日龄内进行消化实验，8 周龄试验结束后禁食剖杀。结果表明，3 组犊牛全期增重分别为 21.6kg、25.0kg 及 24.3kg，ADG 分别达到 515g/d、595g/d 及 579g/d。各组犊牛对日粮氨基酸的表观消化率无显著差异 ( $P > 0.05$ )。CY 组犊牛血清 BUN 含量较低，血清 TP 含量较高。CY 组犊牛瘤胃乳头及瘤胃功能发育较高；赖氨酸水平对犊牛小肠结构形态发育影响不显著 ( $P > 0.05$ )。

本研究得出以下结论：①利用代乳品对犊牛进行早期断奶不影响其增重和体尺发育。②饲喂植物性蛋白质代乳品不影响 2~8 周龄犊牛的生长成绩和消化代谢；日粮植物性蛋白质含量增加有利于犊牛瘤网胃的早期发育。③日龄及日粮蛋白质水平对犊牛常规营养素的表观消化率及血清代谢指标均有显著影响；22% 的蛋白质水平可促进犊牛瘤胃功能发育；高蛋白质水平不利于犊牛肠道的结构发育。④以生产性能为衡量指标，2~8 周龄早期断奶犊牛日粮适宜的赖氨酸水平为 1.80%；日粮赖氨酸水平对犊牛肠道形态学结构无显著影响。

**关键词：**犊牛，早期断奶，蛋白质，表观消化率，胃肠道结构形态

## Effects of Protein Level and Sources on Nutrient Utilization and Gastrointestinal Development of Early Weaned Calves

LI Hui (2008)

Preruminant calves were used as animal models to study the effects of protein level and sources, lysine level in milk replacers on growth performance, digestive physiology, serum biochemical parameters, and gastrointestinal development. The present research consists of five experiments which were listed as follow.

### **Experiment 1: Effect of weaning age on growth performance of early weaned calves fed milk replacer**

In this experiment, 25 neonatal healthy Holstein calves were allotted to five treatments. Calves were fed fresh milk over the entire experiment in the control (C treatment). Calves were weaned off milk from 6, 16, 26 and 36 days of age respectively, and labeled as 6E, 16E, 26E and 36E treatment. The results showed that BW and ADG of 6E treatment were greater than that of C treatment ( $P < 0.05$ ). Body length and heart girth of 6E and 16E treatments were greater than that of C treatment ( $P < 0.05$ ).

### **Experiment 2: Grow performance, nutrients digestibility and gastrointestinal characteristics of dairy calves fed milk replacers with different protein sources**

In this experiment, 15 neonatal calves were allotted to three treatments: calves were fed three types of milk replacer and the ratio of milk protein to plant protein was 80 : 20 (S20), 50 : 50 (S50) and 20 : 80 (S80), respectively. A metabolism trial of 10d duration was conducted to all the experimental calves from 46 day to 55 days of age. Three calves in each treatment were slaughtered at the end of experiment. The results showed that no differences was observed in grow performance and nutrients digestibility among three treatments ( $P > 0.05$ ). Plant protein might be good for development of rumen-reticulum of calves. Organ index of liver and pancreas calves were affected by protein sources ( $P < 0.05$ ). Dietary protein sources affected small intestines morphological criteria, however, no difference was detected in the ratio of villous height to crypt depth ( $P > 0.05$ ).

### **Experiment 3: Effects of different protein levels in milk replacers on nutrients digestibility in preruminant calves**

Nine healthy neonatal calves were selected, randomly divided into three treatments and fed three milk replacers with different protein levels (18%, 22%, 26%) respectively, labeled as LP, MP and HP. Digestion trials were conducted between 12 to 20 days, 22 to 30 days, 32 to 40 days, 42 to 50 days, and 52 to 60 days. The results showed that DM apparent digestibility declined gradually with age, whereas, CP and EE apparent digestibility increased slightly. DM and EE apparent digestibility increased with the increase of dietary CP levels, however, CP apparent digestibility in MP treatment was greater than that in other treatments. BUN concentration increased with the increase of dietary CP levels ( $P < 0.05$ ), but the greatest GLU and TP concentrations were found in

MP treatment at the end of the trials.

#### **Experiment 4: Grow performance, nutrients digestibility and gastrointestinal development of dairy calves fed milk replacers with different amounts of protein**

In this experiment, 15 neonatal calves were randomly allotted to three treatments with different protein levels (18%, 22%, 26%) respectively, labeled as LP, MP and HP. Rumen liquid was sampled prior to morning feeding at 4-w, 5-w, 6-w and 7-w of age. Three calves of each treatment were slaughtered at the end of experiment. The results showed that BW gain was 25.1 kg, 34.8 kg and 26.4 kg respectively. Protein levels had no effect on AA apparent digestibility ( $P>0.05$ ). 22% protein level might be advantage for the development of rumen papilla of calves, and VFA production ( $P<0.05$ ). Dietary protein levels could affect small intestines morphological criteria ( $P<0.05$ ), and the ratio of villous height to crypt depth decreased as dietary crude protein levels increased.

#### **Experiment 5: Grow performance, nutrients digestibility and gastrointestinal characteristics of dairy calves fed milk replacers with different amounts of lysine**

In this experiment, 15 healthy neonatal calves were randomly allotted to three experimental treatments and fed with different milk replacers containing 1.35% (LY), 1.8% (CY) or 2.25% (HY) of lysine. A metabolism trial of 7d duration was conducted to all the experimental calves from 48 to 55 days of age. Three calves of each treatment were slaughtered at the end of experiment. The results showed that BW gains of calves was 21.6 kg, 25.0 kg and 24.3 kg, and ADG was 515 g/d, 595 g/d and 579 g/d, respectively. BUN concentration was lowest, but TP concentration was greatest in the CY treatment. Rumen papillae in the CY treatment was better than that in other treatments. However, dietary lysine levels could not affect small intestines morphological criteria ( $P>0.05$ ).

It could be concluded that: ① No difference was observed in growth performance of early weaned calves fed milk replacer. ② Growth performance and nutrients digestibility were not affected by protein sources in milk replacers. Increased percentage of plant protein in milk replacer might be favor for early development of rumen-reticulum of calves. ③ Calves age and dietary protein levels affected nutrients digestibility and serum parameters. 22% protein level might be beneficial to the development of rumen function in calves; however, higher protein level could impair intestinal morphological criteria. ④ Calves fed 1.80% lysine in milk replacer improved growth performance. There was no significant effects of dietary lysine levels on small intestines morphological criteria.

**Key words:** calf, early weaned, protein, apparent digestibility, gastrointestinal characteristics

## 代乳粉中蛋白质水平和来源对犊牛和羔羊肉质、血清指标和胃肠道发育的影响

范志影 (硕士, 2007 年)

本专题系统地研究了不同蛋白质水平代乳粉对犊牛增重、肌肉成分、血清指标、胃肠道发育的影响, 同时也研究了不同蛋白质来源的羔羊代乳粉对羔羊的肌肉成分和血清游离氨基酸含量的影响。

### 试验一: 不同蛋白质水平代乳粉对犊牛肌肉成分、血清指标和胃肠道发育的影响

本试验旨在研究代乳粉中不同蛋白质水平对犊牛增重、肉质、血清指标和胃肠道发育的影响, 以确定犊牛代乳粉中适宜的蛋白质含量。选择 15 头新生健康荷斯坦公犊牛, 随机的分为 3 组, 记为 P18、P22、P26, 每组 5 头, 每头为一个重复。3 个处理组分别饲喂蛋白质水平设置为 18%、22% 和 26% 的代乳粉。试验期为 60d。分别于犊牛 14d、28d、42d 和 60d 时, 每头犊牛称重, 并采集犊牛血清样本, 测定血清生化指标, 测定 60d 犊牛血清游离氨基酸含量。试验结束当天, 每处理组随机选择 3 头试验犊牛屠宰, 于背最长肌取部分肌肉, 测定肌肉化学成分, 称量犊牛各胃室重量, 小肠按解剖位置分成十二指肠、空肠、回肠三段, 观察各肠段黏膜形态的变化。得到如下结果: ①代乳粉中 18% 蛋白质水平不能满足犊牛的生长需要, 犊牛的增重速度最低; 22% 蛋白质水平条件下犊牛增重量最大; 代乳粉中蛋白质含量过高可导致犊牛增重量的降低。②18% 蛋白质水平代乳粉导致犊牛肌肉蛋白质含量减少, 脂肪含量增加。饲喂 22% 和 26% 蛋白质水平代乳粉的犊牛肌肉中蛋白质、脂肪、水分含量差异不显著。③饲喂 18% 蛋白质水平代乳粉的犊牛体脂肪中脂肪酸组成显著变化, 饱和脂肪酸和单不饱和脂肪酸比例提高, 多不饱和脂肪酸比例显著下降。④18% 蛋白质水平代乳粉使犊牛肌肉氨基酸总量和必需氨基酸含量减少。⑤不同蛋白质水平代乳粉对犊牛血清中各项生化指标 (包括血糖、总胆固醇、尿素氮、总蛋白、白蛋白、球蛋白、乳酸脱氢酶和碱性磷酸酶) 有不同程度的影响, 18% 蛋白质水平代乳粉导致犊牛血清球蛋白含量下降、血清游离氨基酸模式发生变化, 而 26% 蛋白质水平代乳粉导致血清乳酸脱氢酶活性上升。⑥代乳粉中蛋白质含量为 18% 时, 犊牛瘤胃、网胃发育缓慢。⑦代乳粉中蛋白质水平为 26% 时, 使犊牛小肠黏膜形态发生改变, 有绒毛变短、隐窝加深的现象。

### 试验二: 不同蛋白质来源代乳粉对羔羊肌肉成分和血清游离氨基酸的影响

本试验旨在探讨乳源蛋白质代乳粉和植物源蛋白质代乳粉对羔羊肉质和血清游离氨基酸含量的影响, 了解不同来源蛋白质在羔羊肌肉和血清中的代谢差异, 为羔羊代乳粉蛋白质原料的选择提供参考。选择体重、出生日期相近的小尾寒羊 21 只, 随机分为 3 组, 每组 7 只, 其中 A 组为对照组, B 和 C 组为试验组。A 组于整个试验期由母羊哺乳, B、C 组羔羊于 10 日龄断奶, B 组供给乳源性蛋白质原料代乳粉, C 组供给植物性蛋白质原料代乳粉。试验期为 90d。试验结束当天, 采集羔羊血清测定游离氨基酸含量。每处理组随机选择 3 只羔羊屠宰, 测定肌肉化学成分。结果表明: 饲喂乳源蛋白质代乳粉的羔羊, 肌肉中沉积更多的脂肪, 水分含量显著减少, 对蛋白质的含量没有显著影响。饲喂乳源蛋白质代乳粉或植物源蛋白质代乳粉的羔羊与母羊喂养的羔羊相比肌肉氨基酸含量无显著差异, 对羔羊体脂中脂肪酸



组成有显著影响。两种代乳粉显著提高了羔羊体脂肪中多不饱和脂肪酸含量,单不饱和脂肪酸和饱和脂肪酸含量显著下降。饲喂代乳粉对羔羊血清游离氨基酸含量影响不显著。

通过以上研究发现,18%蛋白质水平代乳粉不能满足犊牛快速生产的需要,导致犊牛发育缓慢,而且低蛋白质摄入量使犊牛肌肉中蛋白质合成受阻,未被利用的能量以脂肪形式沉积,肌肉中必需氨基酸含量减少,饱和脂肪酸比例增加,对犊牛肉品质量有不良影响。而且饲喂犊牛低蛋白质水平代乳粉使犊牛血清中球蛋白含量减少,血清氨基酸模式发生改变,对犊牛的健康不利。而喂给犊牛26%蛋白质水平代乳粉使犊牛小肠黏膜受损,影响营养物质的吸收,使犊牛增重速度下降,造成蛋白质资源的浪费。代乳粉中蛋白质水平为22%时,犊牛增重量最大,犊牛肉质处于较佳水平,且对犊牛健康无不利影响。乳源蛋白质和植物源蛋白质代乳粉使羔羊肉中多不饱和脂肪酸比例增加,饱和脂肪酸比例下降,使羔羊肉的功能性增强。本研究为代乳粉的科学配制、为生产优质功能性犊牛肉和羔羊肉提供了借鉴数据,因此具有重要的意义。

本试验将代乳粉中蛋白质水平及来源与犊牛和羔羊的肉质调控相联系,具有一定的创新性。

**关键词:** 代乳粉, 蛋白质, 犊牛, 羔羊, 肌肉成分, 血清指标, 胃肠道发育