



Universiteit  
Leiden  
The Netherlands

## Metabolomics insight into the gut microbiome of infants with cow's milk allergy

Zhu, P.

### Citation

Zhu, P. (2026, January 13). *Metabolomics insight into the gut microbiome of infants with cow's milk allergy*. Retrieved from <https://hdl.handle.net/1887/4286434>

Version: Publisher's Version

License: [Licence agreement concerning inclusion of doctoral thesis in the Institutional Repository of the University of Leiden](#)

Downloaded from: <https://hdl.handle.net/1887/4286434>

**Note:** To cite this publication please use the final published version (if applicable).

# **Metabolomics Insight into the Gut Microbiome of Infants with Cow's Milk Allergy**

Pingping Zhu

朱萍萍

The publication of the thesis was financially supported by:

Leiden University Libraries

*Cover design:* **Tingting Zhu & Yan Zhu**

*Thesis lay-out:* Pingping Zhu

*Printing:* Ridderprint | [www.ridderprint.nl](http://www.ridderprint.nl)

© Copyright, Pingping Zhu, 2025

ISBN: 978-94-6537-050-7

All rights reserved. No part of this book may be reproduced in any form or by any means without permission of the author.

# **Metabolomics Insight into the Gut Microbiome of Infants with Cow's Milk Allergy**

## **Proefschrift**

ter verkrijging van de graad van doctor aan de Universiteit Leiden,  
op gezag van rector magnificus prof.dr.ir. H. Bijl,  
volgens besluit van het college voor promoties  
te verdedigen op dinsdag 13 januari 2026

klokke 10:00 uur

door

**Pingping Zhu 朱萍萍**

Geboren te Chongqing, China

in 1992

**Promotor**

Prof. dr. T. Hankemeier

**Co-promotor(es)**

Dr. A.C. Harms

Dr. ir. A.C. Dubbelman

**Promotiecommissie**

Prof. dr. M. van Eck

Prof. dr. E.C.M. de Lange

Prof. dr. H.P. Spalink

Dr. R.C. van Wijk

Dr. J. Kirwan

*University of Veterinary Medicine Vienna, Austria*

Prof. dr. A. Zhernakova

*University of Groningen, the Netherlands*

The research described in this thesis was performed at Metabolomics and Analytics Center (MAC) of the Leiden Academic Centre for Drug Research (LACDR), Leiden University (Leiden, The Netherlands). The research was financially supported as indicated in each chapter.

# Contents

## Chapter I

General Introduction and Scope	1
--------------------------------	---

## Chapter II

Development of an untargeted LC-MS metabolomics method with post-column infusion for matrix effect monitoring in plasma and feces	19
---	----

## Chapter III

Matrix effects in untargeted LC-MS metabolomics: from creation to compensation with post-column infusion of standards	89
---	----

## Chapter IV

Current insights into cow's milk allergy in children: microbiome, metabolome and immune response – a systematic review	135
--	-----

## Chapter V

Exploring the fecal metabolome in infants with cow's milk allergy: The distinct impacts of cow's milk protein tolerance acquisition and of synbiotic supplementation	175
--	-----

## Chapter VI

Conclusions and Perspectives	217
------------------------------	-----

## Appendix

Summary	232
Samenvatting	236
Curriculum vitae	240
List of Publications	241
Acknowledgements	243