### DEVELOPMENT OF PLANT AROMATASE INHIBITOR NANOPARTICLES FOR MASCULINIZATION OF ZEBRAFISH (Danio rerio)



GRADUATE SCHOOL CHIANG MAI UNIVERSITY JULY 2016

### DEVELOPMENT OF PLANT AROMATASE INHIBITOR NANOPARTICLES FOR MASCULINIZATION OF ZEBRAFISH (Danio rerio)



A THESIS SUBMITTED TO CHIANG MAI UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY IN NANOSCIENCE AND NANOTECHNOLOGY Copyright by Chiang Mai University A I I i g h t s r e s e r v e d

### GRADUATE SCHOOL, CHIANG MAI UNIVERSITY

#### **JULY 2016**

## DEVELOPMENT OF PLANT AROMATASE INHIBITOR NANOPARTICLES FOR MASCULINIZATION OF ZEBRAFISH (Danio rerio)

ACTING SUB LT. TANONGSAK SASSA-DEEPAENG

THIS THESIS HAS BEEN APPROVED TO BE A PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN NANOSCIENCE AND NANOTECHNOLOGY

**Examination Committee:** 

(Prof. Dr. Kazuhisa Sekimizu)

(Asst. Prof. Dr. Surachai Pikulkaew)

(Assoc. Prof. Dr. Siriporn Okonogi)

(Asst. Prof. Dr. Wasana Chaisri)

Phyphiehar W (Lect. Dr. Phenphichar Wanachantararak)

19 July 2016

Copyright © by Chiang Mai University

**Advisory Committee:** 

Asst. Prof. Dr. Surachai Pikulkaew)

(Assoc. Prof. Dr. Siriporn Okonogi)

(Asst. Prof. Dr. Wasana Chaisri)

erved

b

# To My beloved parents

For being first teacher and being my guardian during my educational career

All my teachers

For supporting and encouraging me to believe in myself

**ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่** Copyright<sup>©</sup> by Chiang Mai University AII rights reserved

HAT CMAI

#### ACKNOWLEDGEMENT

I would like to thank all people who contributed in different ways to my work described in this thesis. First and foremost, I really need to thank my academic advisor, Assistant Professor Dr. Surachai Pikulkaew, for sharing me the excellent ideas in developing experimental and giving intellectual freedom. Additionally, I would like to thank my committee members, Associate Professor Dr. Siriporn Okonogi for her contribution of times, and ideas to make my Ph.D. experience in nanoscience productive. I also want to thank Assistant Professor Dr. Wasana Chaisri for providing technical support.

I was fortunate to have the chance to work with Professor Dr. Gen Watanabe, Professor Dr. Kazuaki Takehara, and Associate Professor Kentaro Nagaoka of Tokyo University of Agriculture and Technology. I really want to thanks all for their kindly provided the great experience in doing experimental and gave suggestions. Meanwhile, I would like to thank Professor Dr. Makito Kobayashi, who patiently taught me his techniques in using fish as animal model at International Christian University. Moreover, I am grateful for the constructive suggestions from Prof. Dr. Kazuhisa Sekimizu of Teikyo University.

I would like to thank Professor Dr. Prachaya Kongtawelert, Assistant Professor Dr. Sakornrat Khongkhunthian, Assistant Professor Dr. Kassara Pattamapun, and Dr. Penpitcha Wanachantararak for their kindly provided some financial supports. Moreover, I also gained a lot of knowledge on cell culture and microsome preparation technique from Assistant Professor Dr. Ariyapong Wongnoppavich and Assistant Professor Dr. Rawiwan Wongpoomchai.

I am grateful for the main funding sources that allowed me to pursue my graduate school studies: Rajamangala University of Technology Lanna, and the Graduate School of Chiang Mai University. The nanoparticle effect investigations discussed in this dissertation would not have been possible without the technical support from scientists, technician group, and veterinarian from Faculty of Pharmacy and Faculty of Veterinary Medicine, Chiang Mai University. I have appreciated their collaboration.

I would like to thank the various members of the pharmacy and nanoscience group with whom I had the opportunity to work and have not already mentioned. They provided a friendly and cooperative atmosphere at work.

Finally, special recognition goes out to Mr. Yuya Furukawa who inspired me, provided constant encouragement, and supporting in all my pursuits of Doctorate in Nanoscience and Nanotechnology.



**ลิขสิทธิ์มหาวิทยาลัยเชียงใหม** Copyright<sup>©</sup> by Chiang Mai University AII rights reserved