UNIVERSITI PUTRA MALAYSIA

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2011

DIETARY LIPID REQUIREMENTS OF JUVENILE MALAYSIAN MAHSEER (*Tor tambroides* Bleeker)

By

EHSAN RAMEZANI FARD

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

Nov 2011

DEDICATION

This thesis is dedicated to my beloved mother and father, Nasrin and Mohammad, who have supported me all the way since the beginning of my life.

This thesis is also dedicated to my wonderful wife, Marjan, who has been a great source of motivation and inspiration and has endured difficulty in living with a student. She put her life and career on hold; sacrificing more than any person should to make this work reality. We finally made it.

Finally, this thesis is dedicated to the memory of my late father in law, Jamal Namjoo, who was always treating me like a very concerned father.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

DIETARY LIPID REQUIREMENTS OF JUVENILE MALAYSIAN MAHSEER (*Tor tambroides* Bleeker)

By

EHSAN RAMEZANI FARD

November 2011

Chairman: Associate Professor Mohd Salleh Kamarudin, PhD

Faculty: Agriculture

This study was carried out to determine the effects of dietary lipid level and source on the growth performance and tissue fatty acid profile of juvenile Malaysian mahseer, *Tor tambroides*. An attempt was also made to determine the best dietary lipid composition in term of different fatty acid ratios for this species.

Domesticated wild caught mahseer juveniles were used in all feeding trials. In the first two experiments, four isonitrogenous diets with fish oil as the major source of the oil were formulated in order to provide different dietary lipid levels (5, 10, 15 and 20% as fed basis). In the first experiment, the effects of these diets on the growth performance and final fatty acid composition of fish tissues were studied while in the second experiment, the changes over a six-week time of muscle fatty acid composition were

evaluated. In the third experiment, fish oil was substituted by palm oil, sunflower oil and linseed oil at 50% and 100% ratio. A diet including 100% fish oil (% of total oil in the diet) was also used as a control. In the fourth experiment, juveniles were fed four test diets with a same basal composition but mixed with different oils in a 2×2 factorial experimental design. The two factors were the levels of dietary saturated fatty acid and dietary *n*–3 polyunsaturated fatty acids (PUFA). In the last experiment, three isonitrogenous diets were formulated to contain different linolenic acid/linoleic acid ratios. A diet containing 100% palm oil was also used as a control. At the end of all the experiments, main growth performance variables of fish were estimated. The whole body proximate composition as well as muscle and liver fatty acid profiles were also determined.

The growth of fish linearly decreased with the increase of dietary lipid and the best performance of *Tor tambroides* juveniles was achieved at 5% dietary lipid. However, reduction of *n*–3 PUFA content of fish muscle after six weeks may show that a diet containing high level of *n*–3 PUFA cannot meet all the essential fatty acid requirements of *T. tambroides*. Replacement of dietary fish oil with palm oil improved the growth performance. However, percentage of replacement had no significant effect ($P>0.05$) on the growth. *Tor tambroides* fed a diet containing low amount of *n*–3 PUFA (2%) and high amount of saturated fatty acid (38%) showed the best growth performance. Polynomial regression analysis between the ratios of saturated to *n*–3 fatty acid in the diet and final weight gain of fish showed a maximum weight gain at the highest ratio of 15.3. The significant interaction ($P<0.05$) between

dietary saturated fatty acid and *n*–3 PUFA levels was observed for the total *n*–3 PUFA content of both muscle and liver tissues indicating a tissue *n*–3 sparing action by dietary saturated fatty acid. The increase of dietary linolenic acid to linoleic acid ratio did not improve the growth performance of *T. tambroides*. It can be concluded that a diet containing 5% crude lipid with a saturated fatty acid to *n*–3 ratio of 15.3 and a minimum *n*–3 PUFA content of 2.5% (of total fatty acid) can provide the best growth performance, and efficiently maintain the muscle *n*–3 PUFA content of mahseer juveniles.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

KEPERLUAN LIPID DALAM DIET JUVENIL KELAH MALAYSIA (*Tor tambroides* Bleeker)

Oleh

EHSAN RAMEZANI FARD

November 2011

Pengerusi: Profesor Madya Mohd Salleh Kamarudin

Fakulti: Pertanian

Kajian ini dijalankan untuk menentukan kesan kandungan dan sumber lipid dalam diet terhadap pertumbuhan dan profil asid lemak tisu juvana ikan kelah merah, *Tor tambroides*. Komposisi lipid dari segi nisbah asid lemak yang paling sesuai untuk spesies ini juga telah dikaji.

Juvenil kelah liar yang dijinakkan telah diguna dalam semua kajian pemakanan. Dalam dua eksperimen yang pertama, empat diet isonitrogen yang mengandungi minyak ikan sebagai sumber minyak utama, telah dirumus dengan kandungan lipid yang berlainan (5, 10, 15 dan 20% *as fed basis*). Dalam eksperimen pertama, kesan diet terhadap pertumbuhan dan komposisi asid lemak akhir dalam tisu ikan telah dikaji manakala dalam eksperimen kedua, perubahan komposisi asid lemak dalam tisu otot dalam masa enam minggu telah dinilai. Untuk eksperimen ketiga, minyak ikan telah

digantikan dengan minyak kelapa sawit, bunga matahari dan biji rami pada kadar 50% atau 100%. Satu diet dengan 100% minyak ikan diguna sebagai kawalan. Bagi eksperimen keempat, juvana diberi makan empat diet ujian yang mempunyai komposisi asas yang sama tetapi campuran minyak berlainan dalam rekabetuk kajian faktor 2 x 2. Faktor yang diuji adalah tahap asid lemak tepu dan asid lemak tidak tepu *n*–3 (PUFA). Dalam eksperimen terakhir, tiga diet isonitrogen telah dirumus untuk mengandungi nisbah asid linolenik/asid linoleik yang berbeza. Satu diet yang mempunyai 100% minyak kelapa sawit digunakan sebagai kawalan. Pada akhir kesemua eksperimen, pembolehubah prestasi pertumbuhan utama ikan ditentukan. Komposisi proksimat keseluruhan serta profil asid lemak dalam tisu otot dan hati juga telah ditentukan.

Pertumbuhan ikan juvenil *T. tambroides* berkurangan secara linear dengan pertambahan kandungan lipid dan prestasi terbaik dicapai pada 5% lipid. Walaubagaimanapun, pengurangan kandungan *n*–3 PUFA dalam otot ikan selepas enam minggu mungkin menunjukkan bahawa diet yang mengandungi aras *n*–3 PUFA yang tinggi mungkin tidak dapat memenuhi kesemua keperluan asid lemak perlu untuk ikan *T. tambroides*. Penggantian minyak ikan oleh minyak sawit didapati meningkatkan prestasi pertumbuhan. Namun peratusan penggantian tidak memberi kesan yang ketara ($P>0.05$) kepada pertumbuhan. *T. tambroides* yang diberi diet mengandungi jumlah *n*–3 PUFA yang rendah (2%) dan asid lemak tepu yang tinggi (38%) menunjukkan prestasi pertumbuhan yang terbaik. Analisis regresi polynomial antara nisbah asid lemak tepu dan *n*–3 dalam diet dan pertambahan berat

akhir ikan menunjukkan pertambahan berat maksimum dicapai pada nisbah paling tinggi iaitu 15.3. Interaksi yang ketara ($P>0.05$) di antara paras asid lemak tepu dan *n*–3 PUFA dilihat untuk kandungan keseluruhan *n*–3 PUFA dalam tisu otot dan hati yang menandakan bahawa satu tindakan penggantian *n*–3 tisu dilakukan oleh asid lemak tepu. Peningkatan nisbah asid linolenik dan asid linoleik tidak meningkatkan pertumbuhan *T. tambroides*. Kajian menunjukkan diet yang mengandungi 5% lipid kasar dengan nisbah asid lemak tepu: *n*–3 15.3 serta kandungan minimum *n*-3 PUFA 2.5% (jumlah asid lemak) boleh memberikan prestasi pertumbuhan yang terbaik dan mengekalkan kandungan *n*–3 PUFA secara berkesan dalam juvenil kelah merah.

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I certify that a Thesis Examination Committee has met on November 23, 2011 to conduct the final examination of Ehsan Ramezani Fard on his thesis entitled "Dietary lipid requirements of juvenile Malaysian mahseer (*Tor tambroides* Bleeker)" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

Members of the Thesis Examination Committee were as follows:

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of **Doctor of Philosophy**. The members of the Supervisory Committee were as follows:

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Date: 20 December 2011

DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

EHSAN RAMEZANI FARD

Date: 23 November 2011

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