UNIVERSITI PUTRA MALAYSIA

BROODSTOCK NUTRITION OF AUSTRALIAN RED CLAW CRAYFISH CHERAX QUADRICARINATUS (VON MARTENS)

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By

LADAN ASGARI

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

January 2004

Dedicated

To my family for their support.

...and to all enthusiasts of this field.

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

BROODSTOCK NUTRITION OF AUSTRALIAN RED CLAW CRAYFISH *CHERAX QUADRICARINATUS* (VON MARTENS)

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January 2004

Chairman: Che Roos Saad, Ph.D.

Faculty: Agriculture

A series of experiments were conducted to develop least cost feed formulations for red claw crayfish *Cherax quadricarinatus* broodstock based on the gonad, egg protein and essential amino acids content . All diets were developed using least cost feedstuffs and a linear interactive and discrete optimiser software (LINDO).

Prior to evaluation of different formulated diets, the protein and amino acid contents of red claw crayfish broodstock tissues, eggs and newly hatched juvenile under a culture condition were analysed. Increases in ovarian and embryonic proteins content from 10.48 to 65.29 % were observed with the maturation stages of red claw crayfish *C. quadricarinatus*. These results emphasized the critical role of protein as a main structural component in maturation. However, amino acid compositions of gonad and embryonic

tissue of *C. quadricarinatus* were generally remained constent with the possible exception of histidine.

A comparative study on performance of five dietary protein levels (30-50%) on red claw crayfish was carried out. Based on spawning rate, fecundity, hatchability and egg size, a range of 40-45% crude protein and 16.72 kJ g^{-1} (400 kcal 100 g^{-1}) energy were the best/optimal for red claw crayfish broodstock. Eessential amino acids index (EAAI) of all test diets (developed based on available least cost ingredients for red claw crayfish broodstock) were within the best range (0.960-0.996) recommended for crustaceans. Therefore, all test diets were best in terms of protein and essential amino acids sources. In term of biochemical composition, an increase in dietary protein level was also increased the protein content in eggs and muscle. A positive relationship between dietary protein level and protein contents of eggs and muscle of red claw broodstock was found.

A following study later showed that a diet providing 40% protein and 16.72 kJg^{-1} (400 kcal 100 g^{-1}) energy or 45% protein and 14.65 -16.72 kJ g^{-1} (350-400 Kcal 100 g^{-1}) energy could support a higher eggs production and hatchability in red claw broodstock. In this study, at a constant dietary protein level, broodstock performance increased with an increase in dietary energy level. Whereas, feeding red claw crayfish broodstock with lower energy diets resulted in a noticeable reduction in spawning rate and a delay of 2-3 weeks in the time of onset of spawning. The extremely low performance of red claw crayfish broodstock fed with low dietary energy content suggested the important role of energy in its reproduction and metabolism.

This study also demonstrated that different protein-energy ratio diets developed based on least cost ingredients were highly digestible for red claw crayfish broodstock. This results indicated that protein digestibility coefficients obtained for all formulated diets using external marker (Cr_2O_3) and internal markers (crude fibre and ash) were very similar to one-another. This suggested that crude fibre and ash ratio techniques alongside of Cr_2O_3 as a standard marker can also be used as reliable digestibility markers in red claw crayfish nutrition study.

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

PEMAKANAN INDUK UDANG AUSTRALIAN *CHERAX QUADRICARINATUS* (VON MARTENS) DARI

Oleh

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Satu siri eksperimen telah dijalankan untuk menghasilkan rumusan makanan berkos rendah berdasarkan protein gonad, telur dan kandungan asid amino perlu pada induk udang *Cherax quadricarinatus*. Semua makanan dihasil menggunakan bahan-bahan kos rendah dan dirumus dengan perisian interaktif linear dan pengoptima diskrit (LINDO).

Sebelum menilai rumusan diet yang berlainan, satu kajian telah dijalankan ke atas kandungan protein dan asid amino bagi tisu induk udang, telur dan juwana yang baru menetas semasa pengkulturan. Satu peningkatan di dalam kandungan protein ovari dan embrio dari 10.48 kepada 65.29 % didapati dengan peningkatan peringkat kematangan induk udang *C. quadricarinatus*. Keputusan ini menekankan peranan protein sebagai satu komponen struktural di dalam kematangan. Walaubagaimanapun komposisi asid amino

pada gonad dan tisu embrio *C. quadricarinatus* secara amnya adalah sama kecuali asid amino histidina.

Satu kajian bandingan ke atas prestasi lima peringkat (30-50%) protein diet berkos rendah telah dijalankan. Berdasarkan kadar pembiakan, fekunditi, penetasan dan saiz telur, satu julat 40-45% protein kasar dan 16.72 kJ g^{-1} (400 kcal $100g^{-1}$) tenaga telah didapati sebagai julat optima di dalam perumusan diet berkos rendah untuk induk udang. Indek asid amino perlu (EAAI) dalam semuadiet berdasarkan kepada bahan-bahan berkos rendah yang ada untuk induk udang berada di dalam julat yang terbaik (0.960-0.996) yang dicadangkan untuk krustasea. Oleh itu, diet yang dirumus adalah terbaik dari segi sumber protein dan asid amino perlu. Dari segi komposisi biokimia, secara amnya, peningkatan takat protein dalam akan diet meningkatkan kandungan protein dalam telur dan otot. Terdapat hubungan positif di antara kendungsan dalam diet dan kandungan protein telur serta otot induk udang.

Kajian turut menunjukkan bahawa diet yang mengandungi 40% protein dan 16.72 kJ g^{-1} (400 kcal $100g^{-1}$) tenaga atau 45% protein dan 14.62 -16.72 kJ g^{-1} (350-400 Kcal $100g^{-1}$) tenaga boleh membantu pengeluaran telur dan penetasan yang lebih tinggi oleh induk udang. dalam kajian ini, pada takat protein diet yang tetap, prestasi induk turut meningkat dengan meningkatnya takat tenaga dalam diet. Pemberian makanan dengan diet bertenaga rendah kepada induk udang menghasilkan penurunan kadar pembiakan dan melambatkan permulaan pembiakan selama 2-3 minggu. Prestasi rendah oleh induk udang yang diberi makan diet dengan kandungan tenaga rendah

telah menunjukkan penting tenaga di dalam pembiakan dan metabolismenya.

Kajian ini juga menunjukkan nisbah tenaga protein yang berbeza di dalam diet yang dirumuskan dari bahan-bahan berkos rendah adalah sangat mudah dihadamkan oleh induk udang. Kajian seterusnya juga menunjukkan bahawa koefisien kadar penghadaman untuk semua diet yang dirumus dengan menggunakan penanda luar (Cr_2O_3) dan penanda dalaman (gentian kasar dan abu) adalah sama ($P>0.05$). Keputusan ini mencadangkan di samping Cr_2O_3 sebagai penanda piawai, teknik nisbah gentian kasar dan abu turut boleh digunakan sebagai penanda penghadaman untuk kajian makanan udang.

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I certify that an Examination Committee met on 20th January 2004 to conduct the final examination of Ladan Asgari on her Doctor of Philosophy thesis entitled "Broodstock Nutrition of Australain Red Claw Crayfish *Cherax quadricarinatus* (Von Martens)" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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DECLARATION

I hereby declare that this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

L. Asgari

LADAN ASGARI

Date: - 1 JUN 2004

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LIST OF ABBREVIATIONS

AABA	L-α-Amino-η-Butric Acid
AND	Apparent Nutrient Digestibility
ANOVA	Analysis of Variance
AOAC	Association of Official Analytical Chemist
AQB	Aquabind
Arg	Arginine
BHT	Butylated hydroxy toluene
BM	Bone meal
BW	Body weight
CAP	Calcium Propionate
CF	Crude fibre
CH3OH	Methanol
CMC	Carboxy methyl α cellulose
COP	Copra meal
COT	Cottonseed meal
CP	Crude protein
DE	Digestible energy
DMD	Dry Matter Digestibility
DMRT	Duncan Multiple Range Test
DO	Dissolved oxygen
DP	Digestible protein
DW	Dry weight
EAA	Essential amino acid
EAAI	Essential amino acid index

FM	Fish meal
ha	hectare
HCL	Hydrochloric acid
His	Histidine
Ileu	Iso leucine
Kcal	Kilo calorie
Leu	Leucine
LINDO	Linear interactive and discrete optimiser
LV	Lipovitellin
Lys	Lysine
µm	Microgram
Meth	Methionine
MN	Mineral
MT	Metric tonne
N	Normality
NaOH	Sodium hydroxide
NRC	National research council
P/E	Protein / Energy
P: E ratio	Protein: Energy ratio
P30	Protein 30 percent
Phe	Phenylalanine
PO	Palm oil
ppm	Part per million
RB	Rice bran
RM	Ringgit Malaysia
SAS	Statistical Analysis System

SBM	Soybean meal
SD	Standard deviation
SE	Standard error
SEAFDEC	Southeast Asian Fisheries Development Centre
SEM	Standard error of mean
SM	Shrimp meal
TAP	Tapioca flour
Thr	Threonine
TRT	Treatment
Trypt	Tryptophan
UPM	Universiti Putra Malaysia
Val	Valine
VC	Vitamin C
VG	Vitelloenin
VITP	Vitamin premix
VP	Vitellin, egg yolk protein

CHAPTER I

INTRODUCTION

The Background of Study

The total harvest of the world capture fishery reached a maximum level in 1989 (New, 1991) and has recently entered a period of decline (Garcia and Newton, 1994). The decline has been brought by multiple factors including increasing demand, development of wide ranging fishing and processing vessels (Larkin, 1991), environmental degradation and climate change (Donaldson, 1996). Thus, aquaculture production of various fish and shellfish species has been developed as an alternative for fishery industries in many countries, and further development is expected as the demand for fishery products continues to increase and supply from natural sources becomes more limited (Gatlin, 1996). Aquaculture is increasingly recognized as a sustainable means of producing high quality aquatic food for human consumption. Production has increased rapidly during the last decade and especially over the last half decade to the extent that aquaculture accounts for over 20% of the world production of aquatic foods of marine and freshwater origin (Donaldson, 1996).

Among the aquaculture industries, crayfish farming is one of the few industries developed in the United States, European countries and Australia in the latter half of this century (Brown, 1995). Total world production of freshwater crayfish is estimated to be around 70,000 to 100,000 metric tons (MT) per annum (Huner, 1989). Although, the single most important species