COMPARISON OF NUTRITIONAL VALUES OF SMALL-SCALE PROCESSED AND COMMERCIAL FISHMEAL FOR MARINE FISH CULTURE IN SABAH, MALAYSIA

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The materials in this thesis are original except for quotations, excerpts, summaries and references, which have been duly acknowledged.

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ABSTRAK

PERBANDINGAN NILAI NUTRISI BAGI SERBUK IKAN PEMPROSESAN SKALA-KECIL DAN SERBUK IKAN KOMERSIL UNTUK TERNAKAN IKAN AIR MASIN DI SABAH, MALAYSIA

Kajian ini dijalankan untuk menyelesaikan masalah kekurangan bekalan serbuk ikan bagi ternakan ikan air masin di Sabah, Malaysia. Serbuk ikan pemprosesan skala-kecil dinilai sebagai sumber protein bagi ikan air masin dengan membandingkan nilai nutrisinya dengan serbuk ikan komersil. Empat spesies ikan baja (Decapterus macarellus, Rastrelliger kanagurta, Selar crumenopthalmus dan Nemipterus thosaporni) telah dipilih dan diproses menjadi serbuk ikan di hatceri Institut Penyelidikan Marin Borneo, Universiti Malaysia Sabah. Selain itu, empat jenis serbuk ikan komersil (serbuk ikan Malaysia, Peru, Denmark dan serbuk ikan Chile yang telah dirawat dengan enzim) dari pasaran telah digunakan. Kandungan nutrien (jisim kering, protein, lipid, abu dan tenaga kasar serta komposisi asid lemak) bagi serbuk ikan pemprosesan skala-kecil dibandingkan dengan kandungan nutrien dalam serbuk ikan komersil. Komposisi nutrien bagi serbuk ikan pemprosesan skala-kecil terdiri daripada 92-93% jisim kering, 70-74% protein kasar, 8-10% lipid kasar, 14-19% abu kasar dan 19-21 kJ per g kandugan tenaga kasar. Komposisi asid lemak bagi serbuk ikan pemprosesan skala-kecil terdiri daripada 58-67% asid lemak tepu, diikuti dengan 21-31% asid lemak monotaktepu dan 4-6% asid lemak politaktepu. Komposisi nutrien bagi serbuk ikan komersil terdiri daripada 93-97% jisim kering, 56-74% protein kasar, 10-21% lipid kasar, 5-28% abu kasar dan 20-25 kJ per g kandungan tenaga kasar. Komposisi asid lemak bagi serbuk ikan komersil terdiri daripada 22-42% asid lemak tepu, 22-32% asid lemak monotaktepu dan 26-35% asid lemak politaktepu. Selepas itu, nilai nutrisi bagi serbuk ikan pemprosesan skala-kecil yang diproses dari D. macarellus telah dibandingkan dengan serbuk ikan komersil dari Peru melalui ujian biologi. Serbuk ikan dari Chile yang dirawat dengan enzim ditetapkan sebagai kawalan. *Pertumbuhan, koefisien pencernaan dan 'nutrient retention' bagi juvenil Pagrus major yang diberi tiga jenis makanan berlainan dibandingkan. Tiga jenis makanan itu ialah F.ETC (makanan mengandungi 65% serbuk ikan Chile yang dirawat enzim), F.DM (makanan mengandungi 65% serbuk ikan D. macarellus) dan F.PRN (makanan mengandungi 65% serbuk ikan Peru). Juvenil P. major yang diberi makan F.DM menunjukan kadar kemandinan dan kadar pemakanan harian yang tertinggi. Efisiensi pemakanan, 'nutrient retention' dan koefisien pencernaan protein bagi ikan yang diberi F.DM adalah lebih tinggi berbanding dengan ikan yang diberi F.PRN tetapi lebih rendah berbanding dengan ikan yang diberi F.ETC. Koefisien pencernaan tenaga adalah paling rendah bagi juvenil P. major yang diberi makan F.DM. Tiada perbezaan bermakna (P>0.05) bagi koefisien pencernaan lipid antara ikan yang diberi makan F.DM, F.PRN dan F.ETC. Keputusan kajian ini menunjuk serbuk ikan pemprosesan skala-kecil boleh digunakan sebagai sumber protein bagi ternakan ikan air masin.*

ABSTRACT

This study was conducted in order to solve the problems of insufficient fishmeal supply for marine fish culture in Sabah, Malaysia. The nutritional values of small-scale processed fishmeal were evaluated as protein source for marine fish culture in comparison with commercial fishmeal. Four species of trash fish (*Decapterus macarellus, Rastrelliger kanagurta, Selar crumenopthalmus* and *Nemipterus thosaporni*) were selected and processed into fishmeal in the marine hatchery of Borneo Marine Research Institute, Universiti Malaysia Sabah. Another four types of commercial fishmeal (Malaysian, Peruvian, Danish and enzyme treated Chilean fishmeal) were collected from the market. Dry matter, crude protein, lipid, ash, gross energy and fatty acid compositions of small-scale processed fishmeal were compared with those of commercial fishmeal. The nutrient composition of the small-scale processed fishmeal consisted of 92-93% of dry matter, 70-74% of crude protein, 8-10% of crude lipid, 14-19% of crude ash and 19-21 kJ per g of gross energy. The fatty acid composition of small-scale processed fishmeal mainly consisted of 58-67% of saturated fatty acids, followed by 21-31% of monounsaturated fatty acids and 4-6% of polyunsaturated fatty acids. For commercial fishmeal, the nutrient compositions consisted of 93-97% of dry matter, 56-74% of crude protein, 10-21% of crude lipid, 5-28% of crude ash and 20-25 kJ per g of gross energy. The fatty acid composition consisted of 22-42% of saturated fatty acids, 22-32% of monounsaturated fatty acids and 26-35% of polyunsaturated fatty acids. Nutritional value of small-scale processed fishmeal made from *D. macarellus* was then compared to Peruvian fishmeal through biological assays. Enzyme treated Chilean fishmeal was set as a control. Growth performance, apparent digestibility coefficients and nutrient retentions were compared on *Pagrus major* juveniles fed with three different feeds. The feeds were F.DM (feed containing 65% of *D. macarellus* meal), F.PRN (feed containing 65% of Peruvian fishmeal) and F.ETC (feed containing 65% of enzyme treated Chilean fishmeal). The *P. major* juveniles fed with F.DM showed the highest survival and daily feeding rates. Feed efficiency, nutrient retention and protein digestibility were higher than those fed with F.PRN but lower than those fed with F.ETC. Gross energy digestibility was the lowest in those fed with F.DM and crude lipid digestibility was not significantly different (P>0.05) among the three feeds. The results on nutrient contents and nutrient and energy utilization indicated that small-scale processed fishmeal can be used as a protein source for marine fish culture.

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%	percentage
&	and
°C	degree celsius

LIST OF ABBREVIATIONS

AA	arachidonic acid
ACIAR	*Australian Centre for International Agricultural Research*
ADC	apparent digestibility coefficient
ADCP	*Aquaculture Development and Coordination Programme*
AOAC	*Association of Official Analytical Chemists*
BV	biological value
BW	body weight
cm	centimetre
DFR	daily feeding rate
DHA	docosahexaenoic acid
ed.	edited, edition, editor
EPA	eicosapentaenoic acid
et al.	and others, and the rest
FA	fatty acid
FAME	fatty acid methyl ester
FAO	*Food and Agriculture Organisation*
FCR	feed conversion ratio
FER	feed efficiency ratio
g	gram
GC	gas chromatography
h	hour
kg	kilogram
L	litre
m	metre
mg	milligram
min	minute
mL	millilitre
mm	millimetre
MUFA	monounsaturated fatty acid
n-3	omega-3
n-6	omega-6

N	normality
NACA	*Network of Aquaculture Centres in Asia-Pacific*
nm	nanometre
No.	number
NPU	net protein utilisation
OPPS	*Sabah Outline Perspective Plan*
PER	protein efficiency ratio
pg	page
pH	potantra of hydogeni (power of hydrogen)
ppm	part per million
PUFA	polyunsaturated fatty acid
RM	Ringgit Malaysia
rpm	revolutions per minute
s	second
SD	standard deviation
SFA	saturated fatty acid
SGR	specific growth rate
sp.	species
SPSS	*Statistical Package for Social Science*
UMS	*Universiti Malaysia Sabah*
USA	United States of America
µg	microgram
µL	microlitre
µm	micrometre

KEY WORDS

Fishmeal, Marine fish culture, Nutritional value, Biochemical composition, Biological evaluation.

CHAPTER 1

INTRODUCTION

1.1. Aquaculture in Sabah, Malaysia

The government of Malaysia wants to develop and expand the aquaculture industry in Sabah (Galid, 2003). The government has formulated several policies and plans to encourage its citizens to be involved in the aquaculture field (Galid, 2003). Under the National Agriculture Policy, 1984-2000 and Sabah Outline Perspective Plan (OPPS), 1995-2010, the government has been improving marketing facilities and offering other attractive incentives such as granting pioneer status, labour institutional relief and institutional tax credit for those involved in fisheries and aquaculture (Galid, 2003). Recently, under the Ninth Malaysia Plan, a national aquaculture centre will be built in Tawau, Sabah to spur the development of the fisheries and aquaculture sector (Bernama, 2006a).

One of the reasons that the government of Malaysia wants to develop aquaculture in Sabah is due to the geological and morphological advantages of the state (Galid, 2003). Sabah is a maritime state, which is rich in many and various marine resources (Galid, 2003; Bernama, 2006a). More than three quarters of its boundaries is surrounded by the sea. It has a coastline of approximately 1,600 km and total territorial waters of approximately 100,000 square nautical miles (Senoo, 1997, 2001). It also has a tropical climate, with its temperature ranging from 22-34°C, which is suitable for spawning of fish throughout the whole year (Senoo, 1997, 2001).

Thus, Sabah has immense potential for research and development in the breeding of various species of marine fish that are nearly extinct or possess high market value.

Besides the advantages in geological and morphological features, the government of Malaysia also wants to raise the living standard of poor citizens through the development of aquaculture (Bernama, 2006b). The government wants to increase protein intake, provide employment opportunities, increase the income of farmers, and extend the export market for foreign exchange earning (Ang, 1990; Chua & Tech, 1990). Under the Ninth Malaysia Plan, the government of Sabah will also gives special attention to raise the living standard of more than 20,000 poor fishermen in Sabah (Bernama, 2006b). In order to achieve these objectives, the government is planning to increase national aquaculture production from the current 196,874 metric tons (Department of Fisheries Malaysia, 2004) to 600,000 metric tons with an estimated value of RM 6.40 billion annually by the year 2010 (Utama & Nuruddin, 2005).

Sabah has extensive land areas deemed suitable for particular types of aquaculture operations (Senoo, 1997, 2001, 2005; Galid, 2003). Furthermore, fish is one of the highly traded aquaculture commodities and thus has a very good potential for national and regional market development (Galid, 2003). With strong support from the government, the availability of suitable land resources and established technology, the aquaculture industry in Sabah is primed for expansion (Galid, 2003).

1.2. Problems of Feed Supply for Development of Marine Fish Culture in Sabah

Insufficient feed supply is restricting aquaculture development in Malaysia (Utama & Nuruddin, 2005). Utama & Nuruddin (2005) estimated that 590,000 metric tons of aquaculture feeds will need to be imported into Malaysia by the year 2010. This same problem of insufficient feed supply is also constraining the development of aquaculture in Sabah, which is one of the largest contributors to aquaculture production in Malaysia (Department of Fisheries Malaysia, 2004; Utama & Nuruddin, 2005).

Because of the insufficient supply of aquaculture feed, its price keeps increasing. Furthermore, when feed is imported from foreign countries, there are added costs of transportation and tax. Besides this, the nutritional value of feed may spoil during transportation (Sim *et al.*, 2005). All these factors will lead to an increase in the total production cost.

1.2.1. Trash Fish

Currently, the vast majority of marine fish culture in Sabah is based on the non-supplemental feed system where artificial feeds are not used (Utama & Nuruddin, 2005; Sim & Williams, 2005), but instead only trash fish is fed to the fish (Utama & Nuruddin, 2005; Sim & Williams, 2005). Farmers are relying on trash fish as a single feed source especially for marine carnivorous fishes such as groupers (Giri *et al.*, 2004; Utama & Nuruddin, 2005) and snappers (Utama & Nuruddin, 2005). According to Stobutzki *et al.* (2005), approximately 85% of cultured marine fish are dependent on trash fish as the sole feed. The trash fish commonly used in aquaculture are mainly scad, mackerel, selar and nemipterid (Stobutzki *et al.*, 2005; Utama & Nuruddin, 2005). According to Utama and Nuruddin (2005), Malaysia used about 94,000 metric tons of trash fish to produce 9,235 metric tons of marine fishes in 2003 (Table 1.1).

Table1.1: Estimated production of major aquaculture species, which are fed trash fish in Malaysia, 2003.

Scientific name	Common name	Production (metric tons)
Lates calcarifer	Sea bass	3,489
Lutjanus griseus	Mangrove snapper	2,173
Epinephelus sp.	Grouper	1,637
Lutjanus malabaricus	Red snapper	1,229
Lutjanus argentimaculatus	Mangrove red snapper	707
	Total	**9,235**

Source: Utama & Nuruddin (2005).

Many problems occur in using trash fish as the sole feed in aquaculture (Sim & Williams, 2005; Utama & Nuruddin, 2005). Although artificial feeds are the most suitable alternative feed that can be used as a substitute for trash fish, the problems of availability, price and nutritional values are restricting their usage in aquaculture.

The main problem of using trash fish for fish culture is the inconsistent supply (Heng *et al.,* 2004; Sugiyama *et al.,* 2004; Sim *et al.,* 2005). The availability of trash fish is often highly variable and seasonal (Biusing, 1995; Chin, 1998). For example, during the monsoon season limited fishing is carried out because of the rough sea conditions (Biusing, 1995; Chin, 1998). At this time, the supply of trash fish will decrease. Many farmers try to compensate for the problem by stocking or drying the trash fish in the sun during the peak fishing season (Heng *et al.,* 2004; Sim *et al.,* 2005). However, this traditional method may result in dried fish that are decomposing and contaminated with sand, which will decrease the nutritional value of the feed (Early *et al.,* 2001).

The second major problem is the inconsistent price (Stobutzki *et al.*, 2005). As a result of inconsistent trash fish supply, the market price of trash fish also fluctuates depending on the fishing season (Biusing, 1995; Funge-Smith *et al.,* 2005; Stobutzki *et al.*, 2005). During the peak fishing season, trash fish can be easily obtained from the fish market at the cheap price of approximately RM 0.26 per kg (Stobutzki *et al.*, 2005). Conversely, the price of trash fish can fetch up to RM 5.00 per kg during the low fishing season.

The third major problem is the difficulty in maintaining the quality and freshness of the trash fish (Sim *et al.,* 2005). The storage life of trash fish is short and it is difficult to retain the quality of the fish, especially in tropical countries (Edwards, 2004; Edwards *et al.*, 2004; Sim *et al.,* 2005). Even with refrigeration, the nutritional value of fish will decline within a few weeks (Sim *et al.,* 2005). Farmers will need freezers for storage to avoid rapid spoilage. Poor storage will lead to deterioration of feed quality, which in turn will result in poor growth, malnutrition, health problems and possibly mortality of the fish (Thongrod *et al.,* 2004). All these will decrease farm profitability (Edwards, 2004; Edwards *et al.*, 2004).

In addition, feeding trash fish may also result in the transmission of parasites and diseases (Thongrod *et al.,* 2004; Sim *et al.*, 2005). Freezing may kill some parasites, but most bacteria and viruses that cause diseases in fish will be preserved in the frozen trash fish, which can potentially infect the cultured fish and cause outbreaks of disease. As trash fish is readily broken up into small pieces when eaten, as much as 30-50% of the trash fish fed to fish can be lost during the feeding process (Sim *et al.,* 2005). The small pieces of trash fish that are lost during feeding may decompose at the bottom of the cage, leading to localized pollution and water quality degradation (Rimmer, 2004).

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