UNIVERSITI PUTRA MALAYSIA

IRANIAN COTTONSEED MEAL VARIETIES AS SUBSTITUTE FOR SOYBEAN MEAL IN RAINBOW TROUT (*Oncorhynchus mykiss*) FEEDS

SHAHRAM DADGAR

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By

SHAHRAM DADGAR

Thesis submitted to the school of graduate studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the degree of Doctor of Philosophy

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Dedication

“THE END DEPENDS UPON THE BEGINNING”

This Thesis Is Dedicated To My Family and My Late Father *Manouchehr Dadgar*

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

Iranian Cottonseed Meal varieties as Substitute for Soybean Meal in Rainbow Trout (*Oncorhynchus mykiss*) Feeds

By

SHAHRAM DADGAR

Chairman: Associate Profesor Che Roos Bin Saad, PhD

Faculty: Agriculture

This study was set up to investigate the nutritional value and the optimum inclusion level of several Iranian cottonseed meals i.e. *var*. Pak, Sahel and Akra (CSMP, CSMS, and CSMA) as a substitute for soybean meal (SBM) in rainbow trout (*Oncorhynchus mykiss*) feed. Apparent digestibility coefficients (ADC) were calculated in experiment 1 by using an indigestible marker. At the end of this experiment, the ADCs of CSMP, CSMS, CSMA and SBM were measured. Results showed that ADC values for most nutrients of CSMP, CSMS, and CSMA were different from those of SBM and when the varities were compared; ADC values for CSMP (62.7% from DM and 82.4% for CP and 66.6% for crude fat) were higher than the two other CSM varieties i.e. CSMS and CSMA. Three separate studies were carried out to investigate the nutritional value of each Iranian cottonseed meal varieties (CSM) as soybean meal substitute in quality low cost rainbow trout feeds. Six formulated feeds consisting different substitution levels (0, 20, 40, 60, 80, 100%) of SBM with CSMP, CSMS, and CSMA, respectively, were fed to a total of 540 rainbow trout with initial mean body weight of 50 ± 5 g. Fish were randomly stocked into eighteen 100 L. fiberglass tanks with 30 fish per tank and 3 tanks per diet and fed to apparent satiation 3 times a day and 7 days per week for

Abstrak tesis yang dikemukakan kepack Senat Universiti Putra Malaysia sebagai memenuli keperluan untuk ijazah Doktor Falsafah

Penggantian Pelbagai Mil bijikapas Iran bagi Mil Kacang Soya untuk Makanan Ikan Rainbow Trout (Oncorhynchus mykiss)

Oleh

SHAHRAM DADGAR

Pengerusi: **Profesor Che Roos Bin Saad, PhD**

Fakulti: **Pertanian**

Penilaian untuk Pekali Penghadaman Nyata (ADC) bagi pelbagai jenis biji kapas Iran (CSMP, CSMS dan CSMA) dalam kajian 1 telah dikira dengan penggunaan kromik oksida (Cr_2O_3) dalam diet sebagai penanda yang tidak boleh dihadamkan. Kajian 2, 3, dan 4 telah dijalankan untuk mencari nilai pemakanan bagi setiap jenis mil biji kapas (CSM) sebagai pengganti kepada mil kacang soya (SBM) dalam perumusan makanan berkualiti tetapi harga yang rendah bagi ikan trout (*Oncorhyncus mykiss*). Dalam kajian ini, enam jenis formulasi makanan mengandungi pelbagai tahap CSMP, CSMS, dan CSMA (0, 20, 40, 60, 80 dan 100%) menggantikan kandungan SBM dan diberi makan kepada 540 ekor ikan trout yang mempunya min berat badan 50±5 g. Ikan–ikan dimasukkan secara rawak kedalam 18 tangki (100 L) fiber, setiap tangki mengandungi 30 ekor ikan dan setiap formulasi makanan disediakankan untuk 3 tangki dan ikan diberikan makan 3 kali sehari setiap hari selama 60 hari. ADC untuk CSMP, CSMS, CSMA dan SBM dikirakan. Selepas 8 minggu kajian, purata pertambahan berat badan, nisbah pertukaran makanan (FCR) untuk ikan yang diberikan 6 jenis makanan dikirakan. Bagi setiap rawatan, peratus kemandirian adalah

melebihi 98%. Nilai ADC bagi CSMP, CSMS, dan CSMA adalah berbeza dari SBM. Pertambahan berat badan dan peratus kemandirian adalah tidak bererti ($P>0.05$) bagi kumpulan ikan yang diberi makanan CSMP jika dibandingkan dengan ikan yang menerima makanan kawalan, tetapi perbezaan FCR, nisbah pertumbuhan spesifik (SGR), dan pertambahan berat badan harian (DWG) adalah bererti antara ikan yang mendapat pelbagai diet ($P<0.05$). Dalam kajian kesesuian, penggantian sepenuhnya SBM oleh CSMP dan penggantian separa SBM dengan CSMS dan 20% CSMA menunjukkan ianya lebih menguntungkan dan berasaskan analisis gossypol dan jumlah gossypol menunjukkan ianya tidak memberi kesan keracunan keatas hati ikan oleh semua jenis bijikapas Iran (CSMP, CSMS dan CSMA).

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I certify that an Examination Committee has met on 16 June 2009 to conduct the final examination of Shahram Dadgar on his degree thesis entitled "Iranian Cottonseed Meal Varieties as a Substitute for Soybean Meal in Rainbow Trout (*Oncorhynchus mykiss*) Feeds"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:

Chairman, PhD

Professor Madya Dr.Aziz Arshad
Faculty of Agriculture
Universiti Putra Malaysia
(Chairman)

Examiner 1, PhD
Professor Madya Dr. Sharr Azni Harmin
Faculty of Agriculture
Universiti Putra Malaysia
(Internal Examiner)

Examiner 2, PhD
Dr. Mustafa Kamal Abd. Satar
Faculty of Agriculture
Universiti Putra Malaysia
(Internal Examiner)

External 1, PhD
Professor Dr. Roshada Hashim Dekan
Institut Pengajian Siswazah
Universiti Sains Malaysia
(External Examiner)

Bujang Kim Huat, PhD
Professor/Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

This thesis 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:

Che Roos Bin Saad, PhD

Associated Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Chairman)

Abdul Razak Alimon, PhD

Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

Mohd. Salleh Kamarudin, PhD

Associated Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

HASANAH MOHD. GHAZALI, PhD
Professor/Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 16 October 2009

Declaration

I hereby declare that the thesis is based on my original work except for quotations and citation 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.

SHAHRAM DADGAR

Date: 22 July 2008

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List of Abbreviations

ADC	**Apparent Digestibility Coefficient**
ANFs	**Anti-Nutritional Factors**
AOAC	**Association of Official Analytical Chemists**
AOCS	**American Oil Chemists Society**
APD	**Apparent Protein Digestibility**
CF	**Condition Factor**
CP	**Crude Protein**
CRD	**Completely Randomized Design**
CSM	**Cottonseed Meal**
CSMA	**Cottonseed Meal Akra**
CSMP	**Cottonseed Meal Pak**
CSMS	**Cottonseed Meal Sahel**
DWG	**Daily Weight Gain**
FAO	**Food and Agriculture Organization**
FCR	**Feed Conversion Ratio**
FG	**Free Gossypol**
FM	**Fish Meal**
GE	**Gross Energy**
NAS	**National Academy of Sciences**
NRC	**National Research Council**
PER	**Protein Efficiency Ratio**
PWG	**Percent Weight Gain**

SBM	**Soybean Meal**
SE	**Standard Error**
SGR	**Specific Growth Rate**
SBM	**Soy Bean Meal**
TG	**Total Gossypol**
WG	**Weight gain**

CHAPTER 1

Introduction

1.1 Background of study

Fish is a cheap source of high quality animal protein in many developing countries. According to FAO (1997), annual human demand for food fish will increase to about 110 million tonnes by the year 2010. Consequently, total world fish production by fisheries and aquaculture will remain very important for global food security. Today, more attention is given to fish farming because of the fact that on one hand the capture fisheries have long dominated the fisheries sector and over-fishing due to improper fisheries management led to lower production, although it is believed that potential exists in a few cases for further expansion of capture fisheries. In general, it has been recognized that there are upward limits to further expansion of capture fisheries and for this reason, attention has increasingly focused on the possibilities of fish farming.

World aquaculture production, including aquatic plants, reached 45.7 million tonnes by weight and 56.5 billion USD by value in 2000 (FAO, 2002). Global aquaculture production in 2001 showed a further increase to 48.2 million tonnes with a value of 60.9 billion USD. According to FAO (2002), total fish production reached its peak of 12.8 million tonnes in 2001; aquaculture contributes 37.5 million tonnes. Asia is by far the most important continent for aquaculture activity with Iran having a very basic role in

this matter. FAO (2006) reported that Iran was the sixth country among the top ten producers in terms of growth between the years 2002 and 2004.

In Asia and the Pacific region, aquaculture production in China and Southeast Asian countries primarily consists of cyprinids, whiles the rest of East Asian countries such as Japan, are mostly dependant on high-value marine fish. In global terms, some 99.8% of cultured aquatic plants, 97.5% of cyprinids, 87.4% of penaeids and 93.4% of oysters come from Asia and the Pacific. Meanwhile, 55.6% of the world's farmed salmonids is produced by Western Europe, mainly the northern part of the continent. However, carps dominate in the Central and Eastern European regions, both in quantity and in value. Generally, in developing countries, or "The Third World", where the problem of overpopulation is critical, it is believed that fish farming can offer one of the solutions for the ever-increasing food (protein) crisis (FAO, 1997; FAO, 2001).

Aquaculture contribution to global supply of fish increased from 3.9% of total production by weight in 1970 to 27.1% in 2000 and 32.4% in 2004. It provided 20% of global fisheries production (and 29% of food fish) in 1996, and increased to 29.1% of global fisheries production in 2001(FAO, 2002). The share of aquaculture in the total world food fish production is set to increase from 29.1% in 2001 to 38% by the year 2010. According to FAO (1998), aquaculture output grew dramatically during the millennium while capture fisheries production registered a slight increase. In fact, aquaculture has become the fastest growing food production sector of the world, with an average annual increase of about 9.2% since 1970, compared to

capture fisheries with only 1.4% and 2.8% for terrestrial farmed meat production systems (FAO, 2002). Most of the world aquaculture production is carried out predominantly by low-income food-deficit countries (FAO, 1998).

1.2 Statement of problem

It is generally believed that a proportional increase in the production of fish feeds or aquafeeds is required to increase fish farming practices and consequently aquaculture production in developing countries. Aquafeed production is currently one of the fastest expanding agricultural industries of the world with a fast annual growth of 4.5 million tonnes in 1999 to 16.8 million tonnes in 2000 (FAO, 2002). The major bulk of commercial quafeed, especially protein, comes from fishmeal (FM) and soybean meal (SBM). In fact, almost one third of the 122 million tonnes of fish harvested in the year 1997 were used for fishmeal or fish oil production to be used as an animal protein source in producing animal feeds, including quafeed (FAO, 1998). From the total global production of fishmeal in 1996, two million tonnes were used in aquaculture, with 18.85% and 10.9% of them used for salmon and trout production respectively. FAO (1999), estimate that about 40 percent of the total quafeed production is used for carnivorous finfish species.

Soybean (SB) is the main plant protein source in rainbow trout diets but it has its own drawbacks such as its increasing price in Iran (Iranian Agriculture Ministry, 2004). Moreover, since the sugars inherently present in soybeans are water-soluble, some of

these sugars will naturally dissolve into the water before consumed by the fish and thus contribute to the water pollution. SB production is rather localized in some regions of the world such as India, China and Indonesia. FAO (2004) reported that the world production of SB in 1994, 2001, 2002, 2003 and 2004 was 136, 176, 180, 188 and 204 million tonnes, respectively. In Iran, the total SB consumption is about 2.3 million tonnes per year (Iranian Agriculture Ministry, 2004) while SB production has decreased from 0.235 in 1994 to 0.135 million tonnes in 2004, which has increased the share of imported SB in the market and consequently its market price. Besides, apart from fish diet, SB is vastly used in the domestic animal diets as well which this competition has contributed to the increased price of SB.

Furthermore, SB is becoming more expensive and difficult to supply in many developing countries practicing aquaculture. Therefore, the need for alternative protein sources to replace FM and SBM in aquafeeds is obvious. Consequently, the need for research that can introduce technologies for producing practical, cheap and readily available feedstuffs for fish is stressed (FAO, 1997). Hence, it seems that the quest for low-cost practical fish diet that can enhance the development of semi-intensive aquaculture is a worthwhile priority.

Given the current very rapid increase in the intensification of fresh water farming in Asia, intense future competition for limited global supplies of FM and SBM is very likely. It is predicted that strong demand in Asia for available feed resources will have a