UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN OF OYSTER GROW-OUT CULTURE CONTAINER FOR MALAYSIA AQUACULTURE SMALL-SCALE INDUSTRY

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A thesis submitted
in fulfillment of the requirements for the degree of
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DEDICATION

To my beloved mother Wan Azizah binti Yaacob, my wife Asnida binti Mat Daud, my children Ahmad Haziq Firdaus, Ameera Fatinie, Akmal Najwan and Arissa Adeena.

ABSTRACT

The aquaculture industry plays a significant role in the Malaysian economy. The Malaysian Fisheries Department reported a total aquaculture production of 573,600 metric tonnes in 2022. Although fish aquaculture has experienced stable growth, oyster aquaculture, a relatively new endeavour in Malaysia since the 1980s, faces several challenges hindering its rapid development. These challenges include limited seed sources, unproductive production, and slow market growth. This study focuses on addressing these challenges through the development of a new containers for the oyster farming grow-out phase. The research scope emphasises the design and development of new containers tailored to enhance productivity and address specific challenges encountered in oyster farming. Key objectives include protection from predators such as crabs and fish, flexibility in various farming methods, and ergonomic considerations compared to existing basket. Exercising a design and development process, this study systematically evaluates various design options to identify the most practical and effective combinations of functions. The newly designed oyster containers incorporate innovative features, including perforated walls with open-close functionality to facilitate operations while preventing predator entry. The two-tier design optimises vertical farming space and utilises water depth efficiently. The new oyster container can hold an optimal number of oysters, estimated to be between 52 to 66 pieces of marketable size. Ergonomic factors integrated into the design process limit the total weight of the new oyster containers to 10kg, as indicated by the results of the NIOSH lifting equation analysis and a Rapid Upper Limb Assessment (RULA) score of 2 for body posture during fieldwork. This comprehensive approach to container design not only addresses existing challenges but also promotes sustainability and advancement in the oyster aquaculture industry. In summary, this study presents an innovative oyster container design, offering practical solutions to enhance productivity, efficiency and safety in oyster farming operations in Malaysia. These findings contribute to the advancement of aquaculture practices, demonstrating the potential for innovation to drive sustainable growth and development in the aquaculture sector.

REKABENTUK BEKAS PENTERNAKAN KULTUR TIRAM BAGI INDUSTRI AKUAKULTUR BERSKALA KECIL DI MALAYSIA

ABSTRAK

Industri akuakultur memainkan peranan penting dalam ekonomi Malaysia, Jabatan Perikanan Malaysia melaporkan jumlah pengeluaran akuakultur sebanyak 573,600 tan metrik pada tahun 2022. Walaupun akuakultur ikan telah mengalami pertumbuhan yang stabil, akuakultur tiram, adalah satu usaha yang agak baru di Malaysia walaupun telah ada sejak tahun 1980-an, menghadapi beberapa cabaran yang menghalang perkembangannya dengan pesat, ini termasuk sumber benih yang terhad, pengeluaran yang tidak produktif, dan perkembangan pasaran yang perlahan. Kajian ini memberi tumpuan untuk menangani cabaran tersebut melalui pembangunan bekas baru untuk fasa pembesaran penternakan tiram. Skop penyelidikan menekankan rekabentuk dan pembangunan bekas baru yang direka khusus untuk meningkatkan produktiviti dan menangani cabaran tertentu yang dihadapi dalam penternakan tiram. Objektif utama termasuk perlindungan daripada pemangsa seperti ketam dan ikan, fleksibiliti dalam pelbagai kaedah penternakan, dan faktor ergonomik berbanding dengan bekas yang sedia ada. Dengan menggunakan proses rekabentuk dan pembangunan, kajian ini secara sistematik menilai pelbagai pilihan rekabentuk untuk mengenal pasti kombinasi fungsi yang paling praktikal dan efektif. Bekas tiram yang baru direka memasukkan ciri-ciri inovatif, termasuk dinding berlubang dengan fungsi buka-tutup untuk memudahkan operasi dan dalam masa yang sama menghalang kemasukan pemangsa. Rekabentuk bertingkat (2 tingkat) telah mengoptimakan kawasan penternakan secara menegak dan memanfaatkan kedalaman air. Bekas tiram baru dapat diletakkan sebanyak 52 sehingga 66 biji. Faktor ergonomik yang diserapkan dalam proses rekabentuk telah menghadkan berat keseluruhan bekas baru tiram sebanyak 10kg sebagaimana keputusan analisis NIOSH Lifting Equation dan penilaian analisa Rapid Upper Limb Assessment (RULA) pula memberikan skor 2 untuk postur badan semasa melakukan kerja dilapangan. Pendekatan menyeluruh kepada rekabentuk bekas ini tidak hanya menangani permasalahan sedia ada tetapi juga menggalakkan kelestarian dan kelompangan dalam industri akuakultur tiram. Ringkasnya, kajian ini menghasilkan rekabentuk bekas tiram yang inovatif, menawarkan penyelesaian praktikal untuk meningkatkan produktiviti, kecekapan, dan keselamatan dalam operasi penternakan tiram di Malaysia. Penemuan ini menyumbang kepada kemajuan amalan akuakultur, menunjukkan potensi inovasi untuk mendorong pertumbuhan dan pembangunan lestari dalam sektor akuakultur.

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LIST OF ABBREVIATIONS

AD	-	Anno Domini
BC	-	Before Century
CAD	-	Computer-Aided Design
CAE	-	Computer-Aided Engineering
CAM	-	Computer-Aided Manufacturing
DC	-	Direct current
DOF	-	Department of Fishery
EVA	-	ethylene vinyl acetate
FEM	-	Finite Element Method
GDP	-	Gross Domestic Product
HDPE	-	High-density polyetylene
HOQ	-	House of Quality
MMH	-	Manual Materials Handling
MYR	-	Malaysian Ringgit
NSW	-	New South Wales
PDS	-	Product Design Specification
PVC	-	Polyvinyl chloride
QFD	-	Quality Function Deployment
QFD	-	Quality Function Deployment
RULA	-	Rapid Upper Limb Assessement
WMSD/WRMSD	-	Work-related Musculoskeletal Disorders

LIST OF SYMBOLS

σ	-	Stress
A	-	Area
F	-	Load
ε	-	Strain
L	-	Length

LIST OF APPENDICES

LIST OF PUBLICATIONS

The followings are the list of publications related to the work on this thesis:

Arifin, A., Yusuf MA., Wong NLS., 2020. Development of new container for oyster grow-out culture. *Proceedings of Mechanical Engineering Research Day 2020*, pp. 283-284.

Arzul Arifin, Mohd Asri Yusuff, Nur Leena Wong Wai Sin, Kamarul Arifin Zakaria, 2023. Effects of Different Loads Applied on A Newly- Designed Container for Oyster Grow-Out Culture Using Finite Element Analysis. *International Review of Mechanical Engineering (I.RE.M.E.), Vol. 17, N. 6.*

CHAPTER 1

INTRODUCTION

1.1 Background

Fishery is one of the main sectors that contributed to food supply in Malaysia, whether through marine fish landing, or production of aquaculture. The aquaculture industry in Malaysia began in the 1920s, initially involving the cultivation of Chinese carps in former mining pools. This was followed by shrimp farming using trapping ponds in the 1930s, and before the cultivation of blood cockles in mud flats started in the early 1940s (Teh, 2012 cited in Rosita, 2017 and Jumatli and Ismail, 2021). The practice of cage aquaculture was initiated in the early 1970s through the semi-intensive cultivation of shrimp. Since then, this industry has experienced substantial growth in recent years (Kechik, 1995 cited in Jumatli and Ismail, 2021). According to Jumatli and Ismail (2021) aquaculture has been recognised as a key area in the advancement of Malaysia's economy with its extensive involvement resulting in the gradual advancement in industry in many regions of the country. The aquaculture production experienced an increase, rising from about 407,000 metric tonnes in 2016 to over 573,600 metric tonnes in 2022 as shown in Figure 1.1 and Table 1.1, with a value of MYR4 billion (Figure 1.2 and Table 1.2).

Table 1.1 Aquaculture production in Malaysia (tonne) (Department of Fishery Malaysia)

Production Year	2016	2017	2018	2019	2020	2021	2022
Freshwater	103,348.21	102596.83	101,269.88	104,601.56	97,210.32	105,904.01	115,868.31
Brackishwater	304,039.10	324,418.60	290,195.28	307,180.57	302,807.27	311,283.67	457,814.19
Total	407,387.31	427,015.43	391,465.16	411,782.14	400,017.59	417,187.68	573,682.50

Table 1.2 Aquaculture wholesale (Malaysian Ringgit) in Malaysia (Department of Fisheries Malaysia)

Wholesale value RM'000)	2016	2017	2018	2019	2020	2021	2022
Freshwater	789,117.64	728,183.99	711,093.72	780,503.18	766,464.85	856,354.84	982,035.82
Brackishwater	1,994,630.40	2,312,754.80	2,345,908.10	2,524,130.91	2,348,266.83	2,573,986.20	3,034,326.93
Total	2,783,748.05	3,040,938.79	3,057,001.82	3,304,634.09	3,114,731.68	3,430,341.04	4,016,362.74

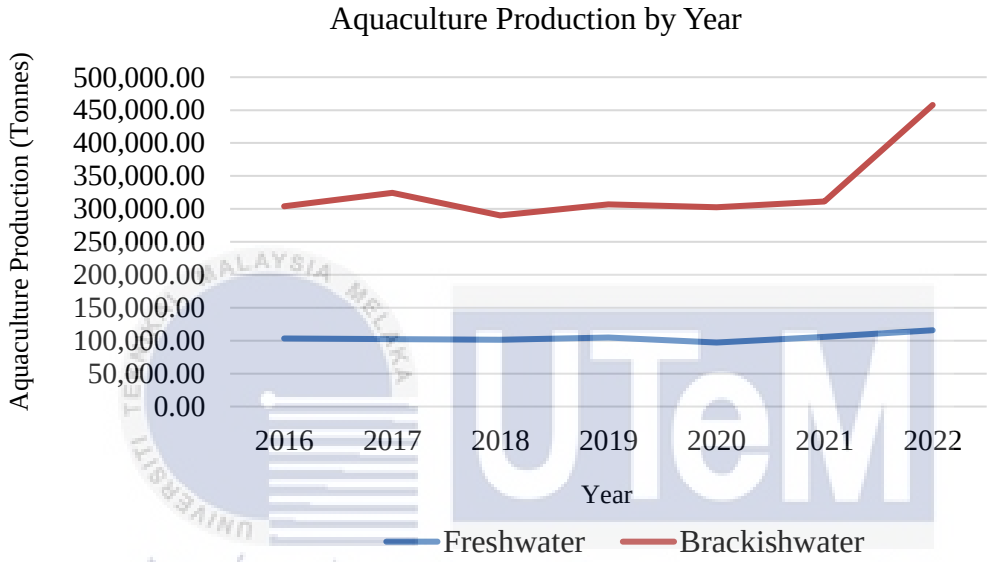

Figure 1.1 Trend of aquaculture production in Malaysia (Department of Fisheries Malaysia)

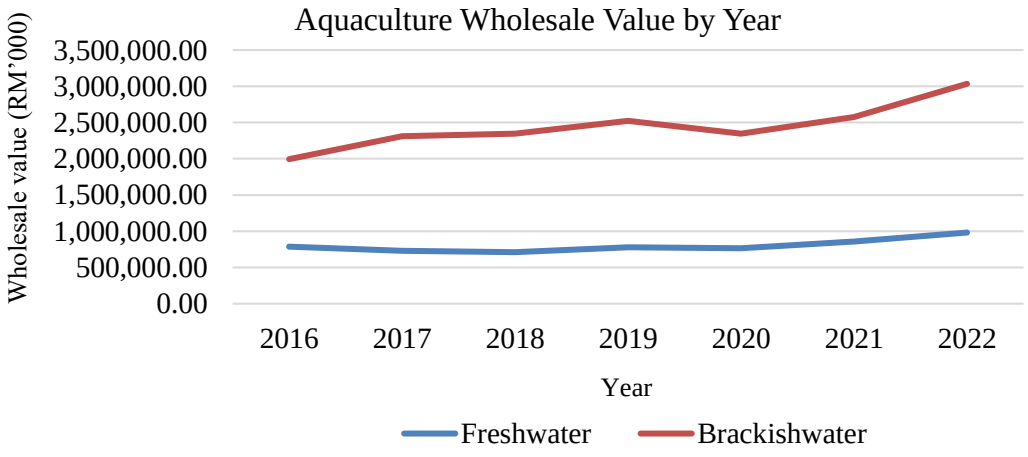

Figure 1.2 Trend of aquaculture wholesale value in Malaysia (Department of Fisheries Malaysia)

The anticipated population growth is projected to drive an ongoing increase in demand. Aquaculture in this country offers employment, business, and investment prospects. In 2017, the number of aquafarmers in Malaysia exceeded 18,000, and the total area of their farms was more than 34,000 hectares. Kamaruddin et al. (2023) states that, a global increase has been observed in aquaculture production from both inland and marine waters. The proliferation of aquaculture production has resulted in the increased fish availability in countries and regions that were previously constrained in their fish options. Concomitant advantages of the expansion include enhanced food security, more competitive pricing, and improved nutrition.

Aquaculture has emerged as the predominant global source of seafood for human consumption since 2016. According to Waiho et al. (2020), seafood serves as a significant protein source and the aquaculture industry plays a crucial role in supporting the livelihoods of coastal communities in Malaysia, namely those engaged in micro- and small-scale fish farming. Aquaculture also contributes as one of the means to provide food security and increase economic value chain to the Malaysians. It can be divided into few main types, fish farming, crustaceans (shrimp, crab, crayfish) farming, mollusc (cockles, oysters, clams and mussles) farming and plant culture. Figure 1.3 and Table 1.3 shows mollusc aquaculture production by main species. Malaysian government, through the Department of Fisheries, had started a programme in 1980's under the Bay of Bengal Programme and International Development Research Centre (Canada) on the introduction of oyster farming in selected areas, involving the local coastal communities (Devakie et al., 1993). Oyster farming is the ideal aquaculture to be promoted to farmers, since it is considered as a clean aquaculture, using green technology (Asche, 2011). No feed is required to grow the oysters, since oysters