

FEATURES

- Status and Strategy for Aquafeed R&D
- Alternative Protein for Aquafeed
- R&D on Fish Feed
- Innovation from Fish Feed R&D



FRI AQUAFEED R&D PROGRAMS

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Message from the Editor

Dear Readers,

Alhamdulillah, I am thankful that for the first time in history, the editorial board managed to publish this year's FRI Newsletter issue on time. It gives us immense joy and satisfaction to present the current issue which emphasises on aquafeed R&D carried out by the FRI.

Global consumption of seafood is increasing while the amount of captured fish is declining. Therefore it is predicted that aquaculture will provide the most reliable supply of seafood in the coming years. With the world's rapidly expanding population, it is important to provide safe and nutritious fish. However there are many issues related to aquafeed and nutrition that need to be considered in order to achieve balance in food production and sustainability. Aquafeed R&D includes the study of nutrients and energy sources essential for fish health, growth and reproduction. Sustainability of the aquaculture industry is an environmental, economic and social concern. This issue features the status on aquafeed R&D by FRI under the Eleventh Malaysia Plan (RMK11) from 2016-2010 which highlights some of the findings and innovations accomplished. There are also some information regarding collaborative work that was planned and on-going between FRI and industrial partners as well as the academia.

To conclude, I would like to thank the contributors of the articles in this issue who submitted technical reports, short communications, updates and photos. We envisage that this could be a great platform for FRI researchers to disseminate their ideas and findings. We hope you find this newsletter informative and useful besides enjoying reading this issue as much as we have enjoyed producing it. If you ever have suggestions or comments, you can reach me at norhana@dof.gov.my

Wan Norhana Noordin

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Status and Strategy of Aquaculture R&D on Feed in Malaysia

By 2020, aquaculture production in Malaysia is targeted to reach 667 thousand metric tonnes (MT) (excluding shells), NAP (2011). In order to support the aquaculture production target, one of the most important factors is to develop cost-effective and sustainable aquaculture feed without compromising on the health status and growth performance of fish/shrimp. Thus, R&D on aquafeed is vital in sustaining aquaculture production in Malaysia.

The strategies taken to tackle issues in aquafeed are in line with the Ministry of Agriculture and Agro-based Industry's -Priorities and Strategies 2019 - 2020. Besides facilitating the production of high-valued marine fish species, farming of omnivorous species such as the whiteleg shrimp, freshwater prawn, tilapia and catfish with low or no fish meal content in diets would be beneficial to the country.

This article presents the status and strategy of aquafeed R&D which is divided into three main scopes i.e aquafeed for broodstock, larvae and grow-out stages.

I. Broodstock stage aquafeed

Broodstock feed or maturation diet is usually expensive and requires special formulation for the production of quality larvae. Most hatchery operators import commercial maturation diets as they are not produced locally. An imported maturation diet for shrimp could fetch up to MYR280/kg (USD68.30/kg). Thus, most of the shrimp/fish broodstock hatchery operators will use unprocessed, raw frozen feed (such as squid, polychaetes, fresh fish or bivalves) as maturation diets which is much cheaper (MYR30/kg (USD7.30/kg)).

Usage of fresh untreated feed could increase the risk of nutritional inconsistency due to different handling methods and seasonal changes. There are also risks of infection from pathogens such as bacteria (*Vibrio* sp.) and viruses eg the White Spot Syndrome Virus (WSSV), Infectious Hypodermal and Hematopoietic Necrosis Virus (IHHNV), Early Mortality Syndrome (EMS) and Enterocytozoon hepatopenaei (EHP) microsporidian which are currently threatening the shrimp aquaculture industry. Besides EHP, the *Macrobrachium rosenbergii* Nodavirus (MrNV) is a viral disease specifically infecting the Giant Freshwater prawn. Meanwhile, the Viral Nervous Necrosis (VNN) is known to infect marine fish in Malaysia.

Besides poor aquaculture management practices, these diseases could also be easily spread via untreated or unprocessed fresh feed. In addition, uncontrolled activities of selling raw infected polychaetes or shrimp as fishing baits further spread the diseases in the wild. Uneaten baits would be consumed by benthic organisms such

as shrimp. Usually, most seasonal hatchery operators capture matured shrimp/prawn broodstock from the wild to produce larvae without any health screening prior to selling or culturing them in open ponds. Further accelerating the spread of diseases is the use of fresh feed captured from infected areas. This unsustainable practice of using fresh untreated feed as food for shrimp/prawn broodstock is common and need to be stopped in order to control disease problems in aquaculture.

Strategy to reduce transfer of pathogens through maturation diets

According to OIE (2010), most pathogens could be inactivated or destroyed when heated or cooked sufficiently. Therefore, an attempt to treat fresh feed using gamma ray was initiated in 2014. After several experiments, the gamma irradiation treatment at 5kGy was deployed to treat fresh feed used for marine shrimp broodstock at FRI Pulau Sayak hatchery. (Mohammed Suhaimee, et al. 2015).

In 2016, FRI had identified a processing and feed formulation technique for the shrimp broodstock. A disease-free moist feed for prawn broodstock called PrimEZeal™ was developed. This innovation won the second place at the Department of Fisheries (DOF) Innovation Competition in 2016. PrimEZeal™ was registered for patent [COF No. PI 2017703947] in 2017. The technical evaluation of PrimEZeal at FRI Pulau Sayak has been initiated and is still continuing. Production attempts at laboratory scale are also underway.

II. Larval stage aquafeed

At present, the use of live feed such as Rotifers and Artemia in larval rearing could not be compensated. Many studies however showed that live feed is also a potential disease carrier (Haliman, 2004; Yan, et al., 2004; Sudhakaran et al., 2007; Escobedo-Bonilla et al., 2008). Conventionally, Artemia was treated with chlorine which act as a disinfectant.

In many countries, chemicals such as permanganate, concentrated chlorine and formaldehyde are still being used in fish and shrimp farms. These chemicals pose health hazards to the workers and could be lethal

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to fish and shrimp. At present, aquaculture products in Malaysia are categorized as "AVOID" by Seafood Watch. One of the factors that affects low scores is the incorporation of antibiotics (eg nitrofurans and sulfonamide) in shrimp feed aimed at preventing disease outbreak.

Strategy to reduce dependency on live feed and use of chemicals

The technology advancement in producing larval stage aquafeed was focussed on reducing or replacing live feed. Nowadays, there are many commercial larval stage aquafeed produced in various sizes: 200, 400, 600, 800 and 1200 microns to suit the mouth sizes or the weight of the larvae. Although the use of imported larval feed are costly, it usually resulted in better survival rates and performances. Due to reduced consumption of the feed during the larval rearing process, the price is not of great concern for hatchery operators.

Most fish and shrimp farmers in Malaysia are moving towards the use of alternative methods to produce healthy fish and shrimp without any antibiotics. Among them is the biofloc technology. This technology uses mild disinfectants, probiotics and mineral mixtures in zero water exchange systems that can improve the performance of fish and shrimp (Mishra et al., 2008; Browdy, et al., 2012; Krummenauer et al., 2014).

In 2018, FRI Pulau Sayak had conducted a study on the effect of chloramine as chlorine alternative for disinfecting water while nursing the post larvae of white shrimp, *Litopenaeus vannamei* (Mohammed Suhaimee, Rosnani and Nor Aida, 2018). Chloramine was found to be effective in eliminating signs of vibriosis and necrosis symptoms throughout the nursing period of 35 days without any adverse effect on shrimp growth.

III. Grow-out stage aquafeed

Generally, the grow-out stage feed accounted for at least 60-70% of the operating costs. The cost of aquafeed for both freshwater and

What insides

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Fresh squid for shrimp broodstock feeding.



Fresh polychaetes used as feed for marine shrimp broodstock.

marine started to increase simultaneously with the increasing price of imported ingredients such as soybean meal, fish meal and fish oil. The World Bank (2013) projected that by 2030, fish meal price would be 13% higher at USD1,488.00/MT while fish oil would be 7% higher at USD1,020.00.

As shown in Table 1, the price of freshwater aquafeed (crude protein, 30%) rose from only MYR2.50/kg (USD0.75/kg) in 2007 to MYR4.00/kg (USD0.89/kg) in 2016 while, the price of marine aquafeed (crude protein, 40%) rose from MYR4.00/kg (USD1.20/kg) in 2007 to MYR6.50/kg (USD1.45/kg) in 2016 (i.e an increment of more than 60%). If the situation is linearly projected, it is estimated that by 2020 the freshwater aquafeed price would reach as high as MYR5.00/kg (USD1.22/kg) and MYR8.10/kg (USD1.98/kg) for marine fish or shrimp aquafeed respectively (Mohammed Suhaimee, 2017).

Since then, most of the small-scale farmers in Malaysia started to use cheaper feed alternatives. Some farmers were discreetly feeding fish with unprocessed and not *toyyib* (good, safe and wholesome) ingredients such as dead chickens or even pigs though Labeling Regulations under the Animal Feed Act (2009) clearly required fish farmers to label or disclose the ingredients used in their aquafeed products. The use of these ingredients had negatively impacted the aquaculture growth in Malaysia. Figure 1 shows an increase in the production of freshwater catfish from 2006 until 2009. But there was a sudden drop (about 50%) from 80 thousand MT (2009) to only 40 thousand MT (2011) in catfish production possibly associated with several news regarding the discovery of pig bones in fish ponds (Kosmo, 2009), use of dead chickens and pigs carcasses (Berita Harian, 10th March, 2017 and The New Straits Times, 24th February, 2019). In addition, the use of unprocessed chicken intestine used directly as fish feed especially for freshwater fish in cage culture system are quite common.

Alternatively, most farmers produce their own farm-made feed instead of commercial pellets. However, there were issues with the availability of raw materials and feed processing equipment. Buying raw materials in small quantities would be very expensive as compared to when buying in large volumes. In addition, due to poor understanding of the digestive physiology of the fish, most fish farmers only processed the premix to form pellets using a mincer

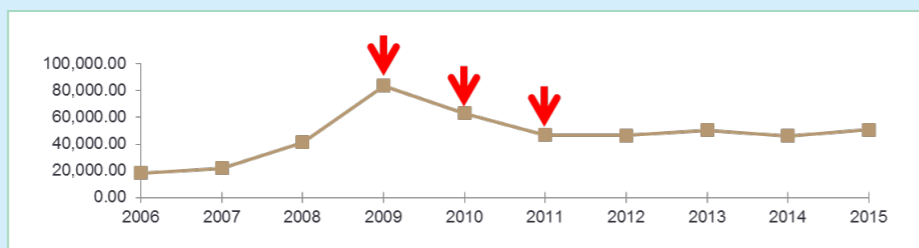


Figure 1: Decreasing production from over 80k MT (2009) to only 46k MT (2011) when there were news highlight on the use of pigs' carcasses in freshwater catfish ponds in 2009. Source: Annual Fisheries Statistics 2006 – 2015.

Table 1: Expected increment of commercial aquaculture feed by 2020 in Malaysia.

Commercial feed	2007	2016	% Increment	2020
Freshwater fish (CP30%)	MYR2.50/kg (USD0.75)	MYR4.00/kg (USD0.89)	+60.0%	MYR5.00/kg
Marine fish/Shrimp (CP40%)	MYR4.00/kg (USD1.20)	MYR6.50/kg (USD1.45)	+62.5%	MYR8.10/kg

Source: Mohammed Suhaimee, 2017.

or a wood pelletizer resulting in poor feed quality and feed conversion ratios. Moreover, without adequate heating, cultured fish could be prone to indigestion and pathogen dissemination from the feed. In order to formulate and produce quality aquafeed, farmers need to be knowledgeable and equipped with appropriate equipments such as scientific and industrial balances, hammer mills, sieves, drying oven, mixer as well as extruder. However, most of these equipments and machineries are costly.

Strategy to reduce the operational and capital costs in aquafeed production by farmers

Assuming the Feed Conversion Ratio (FCR) of freshwater fish/prawn is at 1.5:1, marine fish was at 1.8:1 and marine shrimp at 1.4:1, it was estimated that more than 291,000 MT of aquafeed would be produced either locally or imported from neighbouring countries in 2017. By 2020, While the current local feed millers produced only 170,000MT/year (DOF, 2016), it is estimated that more than one million MT of aquafeed need to be produced yearly as projected in Table 2.

If we assumed the average commercial feed price of freshwater fish/prawn at MYR3.50/kg (USD0.85/kg) and marine fish at MYR6.00/kg (USD1.46/kg), the feeding cost would be at MYR680.8 million (USD166.0 million) for the former and MYR826.1 million (USD201.5 million) for the latter in year 2017.

During an Aquaculture Seed and Feed Action Plan Workshop at Wisma Tani, Putrajaya, March 2016, local feed millers agreed to produce 500,000MT/year of feed by 2020.

The balance of 500,000MT feed would be farm-made by aquaculture farmers. There were almost 16,500 aquaculture farmers in Malaysia (DOF, 2017) and almost all of them were small scale farmers. If only 20% (3,300) of the farmers were to process their own farm-made feed at 500Kg/day for 300 days in a year, an estimated amount of 495,000MT/year of farm-made feed would be achievable.

In order to facilitate these, FRI researchers have approached and advised small and medium local feed millers to produce formulated premixes in powdered form which could be distributed and sold to local farmers. Subsequently, farmers could buy the ready-made premix at a cheaper price since the feed millers are able to buy feed ingredients in large quantities.

Furthermore, fish farmers need not bother regarding the right formula since the feed millers are using the same formulation in producing their own fish pellets commercially. Fish farmers are required to mix the premix with fish or vegetable oil depending on the fish species and add water before extruding



Disease-free PrimeZeat moist feed ready to be given to prawn / shrimp broodstock.

Table 2: Estimate production of commodities and aquaculture feed by 2020 in Malaysia.

No.	Commodities	FCR*	Total production (MT) 2017	Estimated feed (MT) 2017	Target production (MT) 2020	Estimated feed (MT) 2020 ^a
1	Freshwater fish/prawn	1.5	129,685	194,528	311,650	467,475
2	Marine fish	1.8	93,277	137,676 ^b	165,860	298,548
3	Marine shrimp	1.4	68,147	95,405	189,040	264,656
	Total:		291,108	427,609	666,550	1,030,679

*FCR – Feed Conversion Ratio (averaged from various species).

^a Estimated use of 15% trash fish / fish by-catch (FBC) besides pellets.

^b Total usage of pelleted feed without FBC.



Commercially available larval diets.

Fish farmer in Kuala Lipis, Pahang using Masterbite.

Fish farmer in Bota, Perak using Masterbite product.

MSPEX Prototype.

the mixture through an extruder to produce pelleted farm-made aquafeed. The semi-moist pellets could be given directly to cultured fish there after without oven drying to save cost.

Since 2017, one of the small-scale feed millers, Tilapia Maju Agrotech Sdn. Bhd in Pulau Indah had started to produce ready-made premixes called the Masterbite premix which comprised of the same formulation (starter, grower and finisher) as their commercially proven aquafeed called the Masterbite Aquafeed. The use of Masterbite premixes could reduce over 70% of the aquafeed cost from MYR3,500/MT (USD853.70) to only MYR2,500/MT (USD609.80/MT). The Masterbite innovation product won the first place under the Open Category during the Technology Innovation Award Competition field by the Department of Fisheries in 2018.

Meanwhile, in order to produce quality aquafeed, the most suitable machine is an extruder. However, all commercial extruders need to be imported and are costly. To install a small-scale one MT/day capacity extruder could cost up to more than MYR150,000 since the operation needs a three-phase 415 volts electricity supply which requires three-phase wiring. Whereas, most ponds and cages are located in rural areas with 240 volts electricity supply only. Since 2016, a collaboration between FRI and Nuclear Malaysia was initiated to develop a single-phase extruder with a capacity of 500kg/day at a targeted price of below MYR25,000 per unit. After two years of research, a prototype called the Mobile Single-Phase Extruder (MSPEX) was invented whereby farmers could save up to more than 60% of their operational and capital costs. MSPEX won the second place during the DOF Innovation Competition in 2018.

R&D on trash fish, fish meal and fish oil replacement in aquafeed

According to FAO Technical Papers No. 564 (Tacon et al, 2011), by 2020, FAO had targeted the maximum level of fish meal inclusion would be 2% in freshwater fish aquafeed, 12% for marine fish and 8% for shrimps in order to achieve sustainable aquaculture growth. Currently, the fish meal inclusion level in aquaculture feed in Malaysia was estimated at 15% for marine and 11% for freshwater species (Mohammed Suhaimee, 2017).

In 2017, the marine cage culture production was at 36,881.91 MT (Annual Fisheries

Statistics, 2017). With an average FCR of 6.0:1, the available 44,300 MT trash fish or fish by-catch (FBC) could produce only 8,900 MT of marine cage cultured fish species. Due to the high market value of marine fish, it would be possible that most marine cage culture operators alternately fed their fish with commercial pellets. They followed the feeding trend in seabass culture which rely totally on pelleted feed which is either farm-made or commercially prepared since 2013. As for freshwater fish species, total replacement of fish meal and fish oil was established since 2014 especially for the African catfish, *Clarias sp.* (Mohammed Suhaimee, 2017).

Soybean meal (SBM) was identified to be the major plant ingredients which was partially used in replacing fish meal to balance the required protein level. It was recorded that 1.4 million MT soybean was imported into Malaysia in 2014 (USDA, 2016). With an average of 45% crude protein content, it was estimated that a total of 36,246 MT SBM was used in feed for both marine (dietary protein of 40%) and freshwater (dietary protein of 30%) fish species.

Besides SBM, Malaysia also imported 1.5 million MT wheat meal and 3.2 million MT corn meal (USDA, 2016). Unlike soybean, wheat and corn meals have low levels of protein (less than 15% crude protein) but high level of carbohydrate. Utilisation of these energy-based ingredients in aquaculture feed were estimated at 120,000MT in the year 2014. Nevertheless, the cost of soybean, wheat and corn meal fluctuated since they were imported ingredients yet not too costly.

Strategy to reduce the use of fish meal and fish oil in aquafeed

In 2015, Malaysia produced 1.4 million MT of poultry. Poultry by-product and chicken intestine meals were known to have the potential to substitute the use of fish meal in aquaculture feed. In fact, total fish meal and fish oil replacement in diets for African catfish had been achieved since 2014 (DOFM, 2014). Other ingredients known to be used as protein sources were anchovy head wastes and distillers dried grains with solubles (DDGS) but with unknown inclusion level in aquaculture feed.

Several R&Ds on fish meal and fish oil



Kosmo, 18 May 2009

Kosmo, 18 May 2009

Berita Harian 10th March, 2017.

Fish fed with pork-based feed in Penang an isolated case - DOF

By Bernama - February 24, 2019 @ 10:57am

PUTRAJAYA: The recent expose by the Consumer Association of Penang (CAP) that pork-based feed was given to farm fish was that of an isolated case.

The Department of Fisheries (DOF) said it has been regularly conducting halal checks on fish and related products such as fish food and flour since 2010 to trace the presence of porcine DNA.

A total of 846 samples were taken between 2016 and 2018, and only 4.9 per cent was found to contain porcine DNA.

"To curb the problem, immediate action was taken against the fish food supplier, where the main ingredient (protein) was switched to that of a halal source," it said.

The department said that Labeling Regulations under the Animal Food Act 2009 also clearly required manufacturers to label the ingredients in their products, and it was an offence to falsify this information.

"To date, 390 fish breeders have been certified under the Aquaculture Agricultural Certification Scheme (myGAP-Aquaculture) while 17 fish food factories and 12 fish food storage centres have been certified under the Fish Quality Certification scheme," it added. - Bernama

NST, 24th, February, 2019.

RECOMMENDED

Seeking fresh leads death

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replacement in aquaculture feed using insect meal, poultry by-product meal, fermented shrimp head waste, soybean meal, palm oil and soybean oil as well as the use of biofloc technology in white shrimp farming were also studied. Lastly, research and development on fish meal and fish oil substitution in aquafeed with locally available ingredients is still ongoing by DOF Malaysia, universities and private sectors.

In 2011, FRI Glami Lemi had developed an innovative chicken intestine based ingredient called the EcoCIM™ for local feed millers to produce freshwater catfish feed (Utusan Malaysia, 2011).

Strategy to improve feed and feeding practices

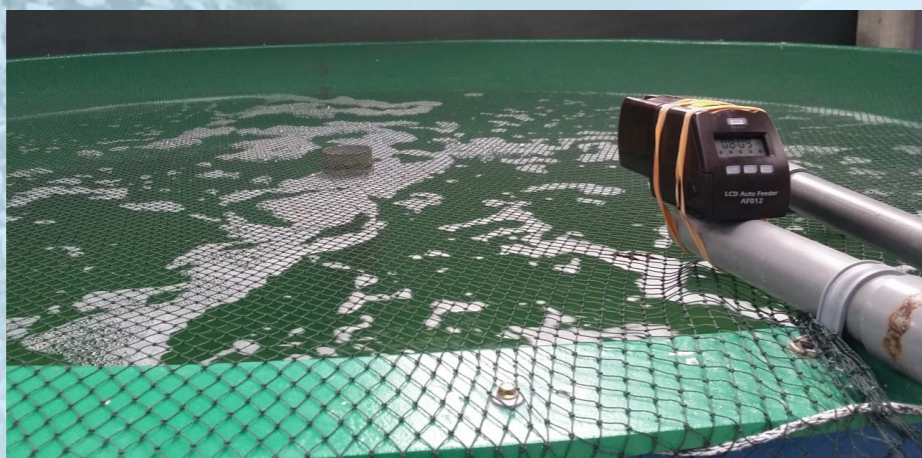
In order to improve feed and feeding practices, FRI organized courses on good aquaculture practices on feed management, feed formulation and fish nutrition for stakeholders (farmers and government officials).

In addition, there were measures taken to monitor feed and feeding practices through auditing processes on aquaculture farms and feed millers in Malaysia based on Good Aquaculture Practices (MyGAP), Feed Store and Feed Mill Monitoring Program under several legislations and regulations such as the Fisheries Act 1985 and Animal Feed Act 2009. DOF Malaysia is also organizing Good Aquaculture Practices Awareness programs among feed millers and farmers to implement relevant rules and acts to reduce the use of unhygienic ingredients, trash fish, fish meal and fish oil.

Conclusion

Research and development of aquafeed in all stages of aquaculture are vital in order to sustain aquaculture production in Malaysia. The strategies taken to solve issues in aquafeed are in line with the Agriculture and Agro-based Industry Ministry's Directive 'Priorities and Strategies 2019 - 2020'. Besides facilitating high-valued marine fish species production, farming of omnivorous aquaculture species such as the whiteleg shrimp, freshwater prawn, tilapia and catfish with low or no fish meal content in diets would be very beneficial to the industry.

Note: All currency exchange rates calculated in this article was based on USD1 = MYR4.10 (May, 2019).



Zero water exchange system in shrimp farming using biofloc technology to reduce pathogen contamination.

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Evaluation of Poultry Processed Protein in Replacing Fish Meal in Cobia (*Rachycentrum canadum*) Diet

Introduction

The aquatic and terrestrial animal feed industry depends on fish meal and fish oil as the main source of protein for the production of formulated feed. Thus alternative protein source is crucial and has become an important area of research. Poultry by-product meal, meat and bone meal, blood meal and feather meal are some of the potential alternative proteins that have been used in the fish feed industry (Allan and Booth, 2010). Poultry by-product meal (PBM) or poultry offal meal (POM) is produced from by-products of the poultry (non-edible parts) processing plant. Although they are of inferior quality due to lower protein content, limited in certain essential amino acids particularly methionine and lysine, lower digestibility and palatability, they are much cheaper and free of anti-nutritional factors. Many studies have been carried out on their nutritional values and optimum use in aquafeed for various fish species and results revealed that they are suitable to be incorporated in fish diets.

PBM is a good alternative to replace fish meal. PBM has protein content of 60-80% and is highly digestible and commercially available in high volumes. The use of PBM as a fish meal replacement had been reported in various fish species such as the Nile tilapia (Soltan, 2009), shrimp (Cruz-Suarez et al., 2007), grouper (Shapawi et al., 2007) and rainbow trout (Steffens, 1994), gilthead seabream (Nengas et al., 1999) and Sea bass (Subhadra et al., 2006; Webster et al., 2000). Since there is limited information on the use of PBM in fish cultured locally, this study was carried out to evaluate the acceptability and the maximum level of PBM that can be incorporated in the diet of marine fish, Cobia (*Rachycentrum canadum*).

Materials and Methods

Preparation of experimental diets

Imported fish meal (FM), local poultry by-product meal (PBM) and poultry feather meal (PFM) were the major protein components used in this study. The PBM and PFM were bought from the Dinding Poultry Processing

Plant in Kg. Acheh, Setiawan, Perak whereas FM was bought from a local dealer. The formulations were developed using different inclusion levels of PBM and PFM in replacing FM protein. The experimental diets were manufactured at FRI Pulau Sayak using the pelletizer machine.

The experimental diets were analysed for proximate and amino acid analysis prior to the feeding trial.

Feeding trial

Procurement of fish

Juvenile cobias (2-5 g) were reared in a cement tank until they attained the desired size. The fish were fed twice daily with commercial diet. Fish sampling was conducted weekly to monitor their growth rate. When the fish attained about 30 g weight, they were transferred into the experimental tanks (300 L and 350 L). The fish were acclimatized for about two weeks during which they were fed on control diet.

Experimental design

The experiment was conducted in conical fibreglass tanks with availability of seawater and freshwater supply and aeration provided. A total of 18 tanks were used for each experiment (Experiment A and B). Flow through system (30L per minute) was used during day time.

After acclimatization, the weight and total length of each fish were recorded and distributed into the experimental tanks. The experiment in randomly assigned tanks was carried out in triplicate for each diet. The fish were hand-fed twice daily at 0900 and 1500 hour. The feeding ratio used was about 7% of the fish biomass. They were fed till satiation and after the second feeding, any excess diet from each tank was weighed and recorded. Fish sampling was carried out at two week intervals by taking the bulk weight and the fish number was counted and recorded. The fish were anaesthetized with MS 222 during sampling to minimize stress and injuries. Based on the biomass recorded

at each sampling, the daily feed amount was adjusted accordingly. At the end of 8 weeks, the weight and total length of fish were recorded.

Water quality (temperature, salinity and dissolved oxygen) was monitored twice daily using thermometer, refractometer and dissolved oxygen meter YSI 500, respectively before feeding throughout the experiment.

Data was analysed using one-way ANOVA (Statistical SPSS version 11.5 for Windows) to compare the significant differences between treatments whereas the Duncan's multiple range test was used to compare their means.

Results and Discussion

All protein sources contained high protein levels (61-85%) and moderate levels of crude lipid (7-14%). The essential amino acid



The experimental diets with different inclusion level of PBM and PFM.

particularly methionine and lysine were lower in PBM and PFM. Methionine content in FM was 4.18% higher than PBM (2.55%) and PFM (0.55%). Similarly, the lysine content in PBM (3.28%) and PFM (2.57%) were lower than FM (4.70%).

Six isolipidic (12% CL) and isoproteic (45%CP) experimental diets were formulated using PBM and PFM to replace fish meal at 20, 40, 60, 80 and 100% dietary protein. The diets with different inclusion levels of PBM and PFM were formulated as in Table 1.

The colour differences of protein sources, imported fish meal, poultry by-product meal and poultry feather meal used in the feed formulation.



Utusan Malaysia, 25th May, 2011.



Blow-fly maggot.



A trainer processing aquafeed using an extruder during Farm-made Feed Training Course at FRI Pulau Sayak, Kedah.



Local farmers and government officials attending Feed and Nutrition Course at FRI Pulau Sayak, Kedah.



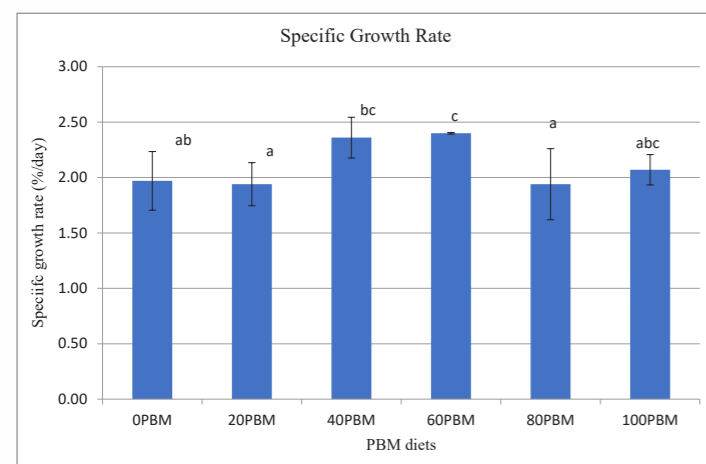
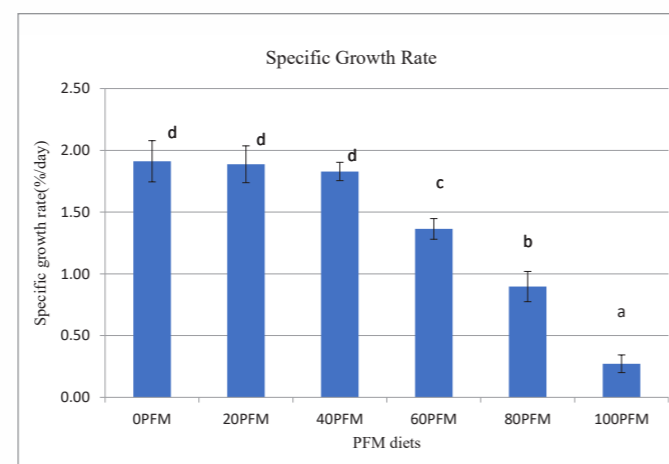
Poultry by-product meal

Poultry feather meal

Imported Fish meal

Table 1: The proximate and amino acid composition of the experimental diets (% dry matter)

Diets	PBM						PFM					
	0PBM	20PBM	40PBM	60PBM	80PBM	100PBM	0PFM	20PFM	40PFM	60PFM	80PFM	100PFM
% of PBM protein	0	20	40	60	80	100	0	20	40	60	80	100
Ingredients (% of dry weight)												
Fish meal	50.0	40.0	30.0	20.0	10.0	0.0	50.0	40.0	30.0	20.0	10.0	0.0
PBM	0.0	12.0	24.0	36.0	48.0	60.0	0.0	8.7	17.4	26.1	34.8	43.5
Soybean meal	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5
Others	38.5	36.5	34.5	32.5	30.5	28.5	38.5	39.8	41.1	42.4	43.7	45.0
Proximate composition (% of dry weight)												
Crude protein	46.6	46.6	47.1	47.0	47.5	48.3	47.2	46.9	46.3	47.0	47.2	47.6
Crude lipid	11.5	12.5	11.4	11.9	12.2	11.1	12.3	11.9	11.3	11.0	13.5	10.9
Ash	11.8	12.5	12.5	13.0	13.4	13.4	11.7	11.5	9.4	8.3	7.3	6.0
Crude fibre	2.7	2.8	3.0	2.6	2.7	2.9	2.8	2.5	2.4	3.0	2.7	3.3
Energy (cal/g)	4759	4706	4537	4155	5084	4332						
Amino acid composition (%)												
Aspartic acid (asp)	3.20	3.40	3.16	3.28	3.36	3.31	2.3	2.8	3.4	3.9	4.4	5.1
Glutamic acid (glu)	5.31	5.60	5.30	5.52	5.79	5.76	4.1	4.8	6.2	7.2	7.9	8.9
Serine(ser)	1.77	1.80	1.72	1.90	1.98	2.03	0.95	1.18	1.15	1.10	1.04	1.26
Glycine (gly)	2.62	2.85	3.00	3.44	3.92	4.40	0.86	0.26	0.23	1.09	1.08	1.14
Histidine (his)	0.99	0.96	0.90	1.02	1.03	1.03	0.31	0.57	0.73	0.27	0.25	0.26
Arginine (arg)	2.75	2.71	2.65	3.03	3.20	3.29	1.04	1.09	0.95	1.10	1.05	1.07
Threonine (thr)	1.77	1.69	1.55	1.69	1.76	1.78	0.60	0.64	0.92	0.67	0.63	0.67
Alanine (ala)	2.50	2.54	2.40	2.53	2.65	2.70	0.88	0.88	0.93	0.85	0.81	0.79
Proline (pro)	2.14	2.19	2.41	2.52	2.83	3.06	0.70	0.86	1.05	1.09	1.10	1.22
Tyrosine (tyr)	0.97	0.94	0.95	1.09	1.15	1.20	0.41	0.23	0.22	0.48	0.44	0.45
Valine (val)	2.23	2.11	1.93	2.01	2.03	2.00	0.80	0.85	0.97	0.96	0.93	0.97
Methionine (met)	2.38	2.14	2.06	1.91	1.85	1.83	4.86	4.70	4.43	1.26	1.43	N.A.
Cystine (cs.Cys)	0.38	0.32	0.34	0.38	0.45	0.49	0.09	0.11	0.12	0.28	0.58	0.43
Isoleucine (ile)	1.98	1.83	1.67	1.74	1.75	1.73	0.64	0.69	0.62	0.74	0.68	0.70
Leucine (Leu)	3.29	3.06	2.84	2.94	2.97	2.92	1.08	1.17	1.28	1.27	1.17	1.21
Phenylalanine (Phe)	1.90	1.75	1.62	1.70	1.72	1.72	0.60	0.67	0.74	0.75	0.70	0.72
Trptophan (Trp)	0.41	0.38	0.37	0.36	0.41	0.30	0.20	0.19	0.31	0.26	0.24	0.18
Lysine (lys)	2.51	2.56	2.31	2.35	2.34	2.27	1.01	0.95	0.92	0.71	0.64	0.58

**Fig. 1:** Specific growth rate (mean \pm SD, n=3) at the end of the experiment (d60) of juvenile cobia fed PBM diets. Means with a common letter indicate not significantly different.**Fig. 2:** Specific growth rate (mean \pm SD, n=3) at the end of the experiment (d60) of juvenile cobia fed PFM diets. Means with a common letter indicate not significantly different.

At the end of the feeding trial in Experiment A, juvenile cobia exhibited very good growth performance and indicated that diets containing high inclusion level of PBM (up to 100%) were well accepted. These findings suggest that it is possible to use FM free diets for cobia without resulting in any negative effect on their growth performance. This finding conforms with previous studies reported by several researchers for other species using PBM in replacing FM. The humpback grouper grew well on a diet with 75% local grade PBM and 100% imported grade PBM (Shapawi *et al.*, 2007), the gilthead seabream (PBM replaced 75% FM) and red seabream (100%PBM) as reported by Nengas *et al.* (1999) and Takagi *et al.* (2000).

The best specific growth rate (SGR) was recorded for fish fed with 60PBM diet ($2.40 \pm 0.01\%/day$), which was significantly higher ($P < 0.05$) than those fed the control diet ($1.97 \pm 0.26\%/day$) (Figure 3). The feed conversion ratio (FCR) of 1.83 ± 0.05 was recorded for fish fed the 60PBM diet which was not significantly different ($P > 0.05$) from those fed with the control diet.

Based on this finding, the amount of PBM usage in cobia diets would be increased up to 60% of their dry weight (100% PBM protein replacing FM protein), hence the amount of FM usage can be proportionally decreased. The results also suggest that the local PBM can be used to replace up to 100% of the fish meal dietary protein in the juvenile cobia diets without any adverse effects on their growth performance. However, the 60PBM diet gave better growth performance as compared to the control and 100PBM diets. Similar patterns were reported for seabass, *Lates calcarifer* where diet containing 50% poultry offal meal and 50% FM protein gave better growth performance than the control diet (Che Utama and Saadiah, 1999).

Meanwhile for Experiment B, the growth performance and feed utilization results of this study indicated that the highest inclusion level of PFM protein was around 40% or 17% of dry weight in juvenile cobia diet. This finding conformed to results of previous studies reported by several researchers on other species. Arunlertaree and Moolthongnoi (2008) reported that fermented feather meal could be used at 25% up to 50 % of the diet level for tilapia, *Oreochromis niloticus* without compromising growth and feed utilization efficiency. However, it appeared to result in a decrease in weight gain and associated growth parameters with increasing replacement level of PFM.

The best SGR was recorded for fish fed with 0PFM diet (1.91 ± 0.16), which was not significantly different ($P > 0.05$) to those fed the 20PFM and 40PFM diets with values at $1.89 \pm 0.15\%/day$ and $1.83 \pm 0.08\%/day$,

respectively as shown in Figure 4. The FCR of 2.17 ± 0.18 for fish fed the 40PFM diet was not significantly different ($P > 0.05$) from those fed the control, 20PFM, 60PFM and 80PFM diets.

However, based on the observation during feeding time, the PFM diets were not well accepted by the fish. This problem was due to the palatability of the diets. The 100PFM diet was totally rejected by the fish and as a result, the experimental fish gave the lowest growth rate and highest FCR. The growth performance and feed utilization criteria from this present study did not actually indicate the true utilisation of PFM diets by the juvenile cobia since the fish refused to consume the feed offered. The acceptability of the diets by the fish decreased as the inclusion level of PFM was increased. Destroyed palatability had been demonstrated to contribute to reduced feed intake and growth of fish fed the diets (Wang *et al.*, 2008). Incorporating feeding stimulants was recommended to improve palatability of fish diets (Papatyphon and Sorares, 2000).

The results from this study suggested that PBM could replace dietary fish meal at 100% without adversely affecting the growth performance of juvenile cobia, but an optimal replacement level at approximately 60% was recommended for better growth performance and efficient feed utilization. Meanwhile, the results using PFM suggested that PFM could replace dietary fish meal at 40% without any negative effect on the growth performance based on tested parameters.

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Moments in FRI



Pre birthday cake for Dr Alias Man after presenting his inaugural speech a day before his retirement on 1st Aug 2019.

The last clock out, Dr Fariduddin as Director of FRI Glami Lemi in June 2019.



Tuan Haji Samsudin Basir submitted the "Nota Serah Tugas" to Dr Zainoddin Jamari just before his final clock out.

Mr Mohd. Saleh Taha from FRI Pulau Sayak showing the attached oyster spat on the plastic lining to the Northern Corridor Implementation Authority representatives (Ms Woon Soo Chin, Dr Muhamad Faiz bin Abdul Rahman and Dr Iskandar Zulkarnain bin Zainal Abidin.



25 Jan 2019, Islamic Innovation Challenge Award by Agensi Inovasi Malaysia (AIM) won by EcoCIM Feed by FRI Glami Lemi and to be commercialized by Amo Biotech Sdn Bhd.



2 Jul: National Consultation of BOBLME Malaysia at FRIBM.



9 Jan 2019: Meeting and visit by Ministry of Finance, Ministry of Agriculture and DOF representatives to amend the FRI Trust Funds scope.



1st suspended coral planting technique recorded in the Malaysia book of records.

12 Mac: Mohammed Suhaimee Abdul Manaf from FRI Pulau Sayak exhibiting his innovation M-SPEX during Hari Bertemu Pelanggan FRI Batu Maung.

Formulation of Floating Feed for Turtles

As a country that is committed towards sea turtle conservation, Malaysia has six Turtle Information Centres set up throughout the country functioning as *ex-situ* incubation sites for collected turtle eggs, releasing the hatchling back to the sea, treatment of injured or sick turtles and rearing turtles for education and tourism purposes. In order to execute these roles, there is a need to hold turtles in captivity. Diets and method of feeding are vital components in rearing or maintaining turtles in tanks, especially when they are not self-reliant to prey on their own. In nature, turtles feed on fish, invertebrate, jellyfish, coral or seaweed. Therefore, turtle feed formulation for those in captivity should simulate their natural diet.

Suitable diet and feeding routine are important to keep turtles healthy and speed up their recovery process if they are injured. Turtle's diet includes fish that are normally hand-fed directly to the turtle's mouth so that they can see and smell the food before consuming. As in the natural habitat, turtles will prey on moving objects. Thus in the tanks, turtles tend to follow the feeder's hand when they are being fed. This method is risky as the feeder's fingers might get bitten by the turtles. If the feed (that is the fish) is just thrown into the water, it might not get the turtle's attention as it is not visible to the turtle's eyes. The feed tend to sink to the bottom of the tank without being noticed and eaten and when this happens, the water quality in tank will be deteriorated.

Hence a study was carried out to produce a better feed for turtle care in captivity in terms of variety, enrichment, being buoyant and convenient to prepare and store. As a Turtle Hospital, Rantau Abang FRI has improved the common feeding method by producing frozen feed cubes by blending the deboned fish and squid. Multivitamins were added to fortify the diet, and was mixed along with melted agar prior to being frozen for use.

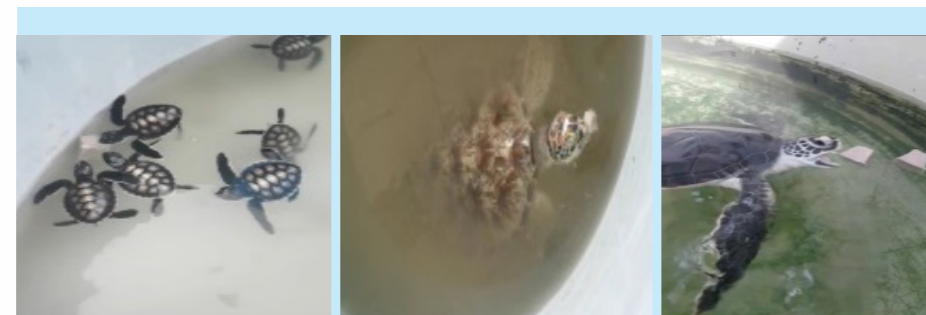
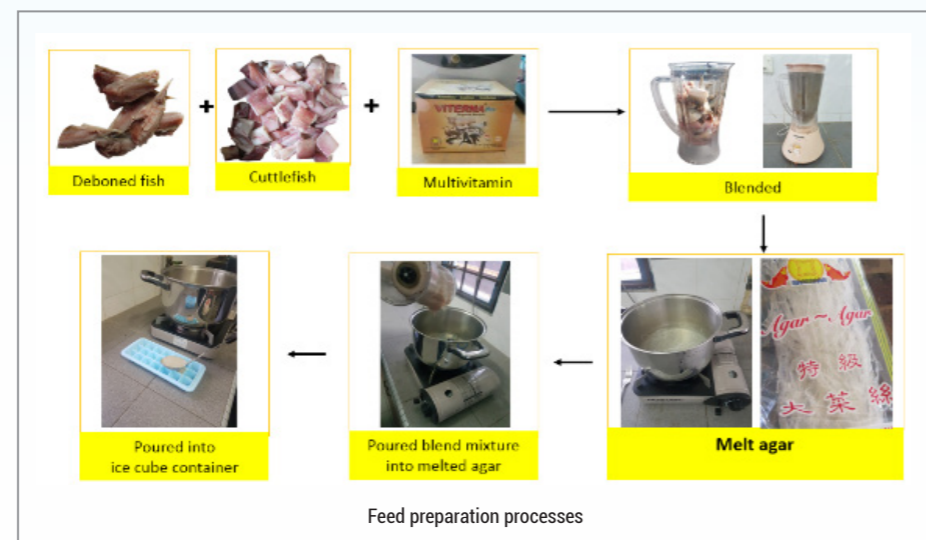
The frozen feed cubes were tested for buoyancy and shape retention ability to

see its reaction in the water column and interaction with the turtles. It was observed that the feed was able to float on the water surface for about 10 minutes which give enough time for the turtles to prey on them. The feed was also observed to be consumed by all turtle species at all life stages: hatchlings, juveniles and adults. Moreover, the constituents of the feed was able to withstand water with the addition of agar as a binder that gave it shape and also served as their natural diet. Agar is derived from seaweed such as *Gracillaria* sp. which serves as a mineral supply to turtle's diet.

This improved feeding method can be applied to all other turtle holding facilities in Malaysia, as the feed comprised of enriched diet variety, feed shape that can maintain and float in the water column, allowing the turtle

Table 1: Frozen feed cube ingredients

Ingredient	Weight (g)	Percentage (%)
Fish fillet	450	45
Squid	100	10
Multivitamin	20	2
Agar	30	3
Water	400	40
TOTAL	1000 g	100%



Floating feed cubes fed to green turtles (from left; hatchlings, juvenile and adult)

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to prey on its own without the need to hand-feed thereby preventing injury to the feeder's hand. Feeding turtle with this floating feed cube is recommended especially for hatchlings that require more nutrients to enhance growth. Besides that, when there is limited sea water for changing water in the tanks, this floating feed will not pollute the water as it will be consumed by the turtle without being left uneaten. Further study is needed to understand turtle diet requirement and their feeding habits for better feeding regime in the future.

Development of a Live Feed Intensive Culture System

Live feed is economically important for larviculture of fish and other aquatic animals. Rotifer (*Brachionus plicatilis*) is a small sized zooplankton with high nutritional value. Rotifers are cultured using a variety of systems, namely batch culture, semi-continuous and continuous culture. In Malaysia, rotifers are most often cultured in open, batch culture systems in tanks or ponds and are fed with microalgae and/or yeast. Although batch culture is relatively simple, the production is often unpredictable and requires considerable labour to operate and maintain. Furthermore, it is also susceptible to unpredictable 'crashes' caused by protozoans and/or other factors. In addition, it is often difficult to operate batch culture for marine species at inland areas or at locations without reliable source of seawater.

Inland hatcheries in Malaysia need to import brine (150–200% salinity) at considerable expense from salt farms located in coastal areas of Malaysia. Effective reuse of this seawater is therefore desirable. These requirements generated considerable interest in the development of closed-recirculation systems for larviculture food production as an alternative to open, batch culture systems. To date, however, most of the commercially available closed systems are too costly, technically complex and difficult to operate and in most cases the systems are not reliable. So by developing our own continuous, closed-recirculation system to culture rotifers for the local hatcheries, the above mentioned problems would be overcome.

Innovation on high density production of rotifer using continuous culture system was conducted for two years (2016-2018) at Fisheries Research Institute Tanjung Demong (FRITD) with funding from RMK11. This continuous culture system consists of culture tank (500L), settlement tank (1 ton), protein skimmer and aeration tank (500L) (Figure 1). Flow of concentrated nutrient (feed) solution from the nutrient source reservoir to the culture tank is controlled by a dosing pump. While feed is pumped, seawater is also pumped from the tanks holding re-used water into culture tank.

The culture tank has a capacity of 500 L and water flow from the recycled/new water tanks will be regulated by a float controlling the water level inside the culture tank. When water volume in the culture tank falls to 20L, re-used water will be automatically and synchronously pumped into the culture tank along with concentrated nutrients. Refill water enters the culture medium tank, and is then recycled through the settling tank by a separate pump. All tanks in the system are made of fiberglass, while all the piping are flexible pipes and tubes of soft PVC.

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Rotifer recirculating system in FRITD

Rotifers were harvested in the rotifer harvest tank using the harvest net (60 µm mesh size). Water flow is by gravity from the culture tank into the harvest net. During harvesting, rotifers were concentrated in the net and rotifers adhering to the net were washed using seawater. Fresh seawater was added after harvesting to compensate the water loss. In addition, the water treatment tanks contain several sub-components designed such as protein skimmer to restore water quality by removing both solid and dissolved wastes and contaminants.

In terms of productivity, the cell counts increased from 360 cells/mL to 15,000 cells/mL in 15 days (Figure 1). After 15 days 1/3% of the culture was harvested. The number of rotifers increased in the next 2 days and was subjected for further harvesting. The rotifers were harvested on alternate days to maintain the maximum level of growth. Comparing the growth in ponds system where the maximum cell density is 80 individuals/mL, the continuous culture system the growth

increased to 15,000 cell/mL, with more than 150% increment in cell growth. Apart from the growth, the continuous culture system also offers more advantage in terms of reduced labour cost. Continuous systems require much less incoming water as compared to pond system, minimizing the discharge to the environment and reduced workload for person in charge.

Water quality in the system was improved by using probiotics in the biological filter which reduced the concentration of ammonia from 1 mg/L to 0.001 mg/L. In this RAS system, the daily water exchange rate was 6.12 L/min or 22%, which gave a positive effect on the rotifer's growth.

In general, it could be demonstrated that the use of a recirculation system has proven to reduce labour and maintenance cost while ensuring stable physico-chemical water parameters resulting in a more reliable (hygienic and axenic) and healthy rotifer supply.

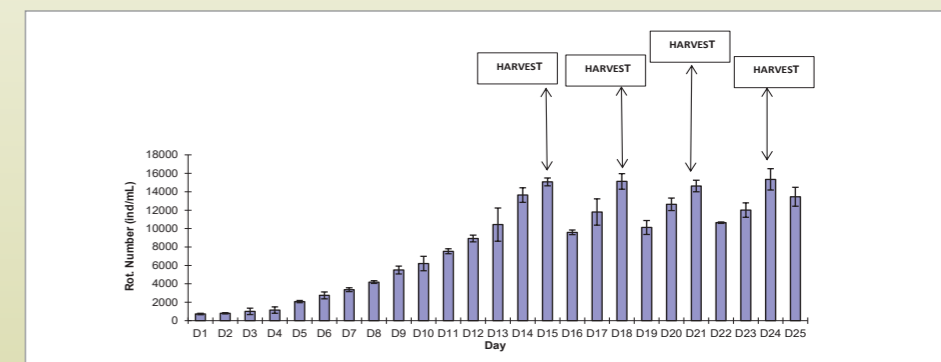


Figure 1: Cell counts

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Technology and Innovation in Aquafeed R&D under the 11th Malaysia Plan

It was estimated that more than 293,000 tonnes of aquafeed in Malaysia was either produced locally or imported in 2015. By 2020, about 1.1 million tonnes of aquafeed will need to be produced yearly based on targeted production. However currently, the local feed millers only produce around 170,000 tonnes per year. During a workshop with local feed millers in March 2016, they agreed to expand their capacity to produce 500,000 tonnes of feed annually by 2020, while the balance of 600,000 tonnes will need to be farm-made.

Therefore, FRI under the 11th Malaysia Plan had identified production of feed as one of the main research focus for the aquaculture R&D. There are several projects that were planned and implemented under this scope of research. Some of the projects have successfully resulted in innovations and new technologies which had successfully won several awards in the competition. Listed below are the various technologies developed which are divided into 4 main types of innovation:

A. High density live feed production

Live feeds basically zooplankton which includes rotifers, moina, copepods, cladoceras and other invertebrates are essential feed during early hatching phase to enhance high larval survival rate.

Submerged Central Rotating Filter (Inventor: Dr Shaharah Mohd Idris, FRI Tg Demong)

Rotifer production has been a challenge in marine aquaculture since local farmers operated an open batch culture system (tanks and ponds) leading to insufficient amount of rotifer supply. Hence, the submerged central rotating filter technology was introduced in close-systems to overcome the previously mentioned difficulties. Benefits from this technology are; high density culture, stabilized productivity, and at the same time, less labour and being cost effective. The improvised filter system is controlled by aeration and deploys a 40 µm filter with a soft brush attached at the end to prevent clogging. The rotifer density increased from 80 individuals/ml up to 15000 individuals/ml with optimized water quality.

Photobioreactor (Inventor: Mr. Teoh Pik Neng, FRI Pulau Sayak)

Energy-efficient photobioreactor was developed to improve the culture method for microalgae *Nannochloropsis* sp. It is comprised of energy efficient lighting – Light Emitting Diodes (LED) with an air-cooled element for the culture vessel. *Nannochloropsis* sp. is an essential live feed in marine finfish larvae culture. Conventionally, these green microalgae are being culture in outdoor tanks and are prone to collapse due to contamination and unfavourable weather conditions. The photobioreactor is a flat panel design with high light intensity from the LED, which is necessary to support high microalgae cell density.



B. Substitution or replacement of fishmeal

EcoCIM Feed (Inventor: Hanan bin Mohd Yusof, FRI Glami Lemi)

The ever increasing price of fishmeal in the market and declining resources have been among the most impactful factors that resulted in high operational cost in the aquaculture sector. Thus, the idea of producing cost effective aquafeed based on cheaper alternative protein source such as from chicken intestine meal was successfully developed. This innovation was named EcoCIM feed. The application of EcoCIM feed enhanced better growth performance with economic operating cost as compared to commercialized pellet using fishmeal as main protein source. The nutritional, effective and eco-friendly CIM feed formulation had been developed and registered as utility innovation (COF No. UI 2016701344). To further validate EcoCIM's potential in the market, a collaborative project is being work out with Amo Biotech Sdn. Bhd. to produce this feed for the local farmers at a commercial level.



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Prawmag Grow (Inventors: Mohammed Suhaimee bin Abd. Manaf, Dr. Ahmad Daud bin Om, Prof. Madya Dr. Zainoha binti Zakaria, Dr. Naji Arafat bin Mahat and Encik Norhisyam bin Ismail)

Prawmag Grow is a feed formulation developed through collaboration between FRI and University of Technology, Malaysia (UTM). Prawmag Grow constitutes Blowfly (BF) specifically known as *Chrysomya rufifacies* and *C. megacephala* for promoting the growth of white shrimp, *Litopenaeus vannamei*. BF are scientifically proven to contribute high protein larvae using fresh chicken waste and thus would be a potential substitute for the meat and bone meal (MBM) as aquafeed. Prawmag Grow had been proven to be effective in terms of its lab-scale performance while at the same time, gave no negative impact on shrimp production. This innovation received an award at the Innovation Award Contest held by the Department of Fisheries Malaysia (2018).



C) Feed Formulation

GrowEZMix (Inventors: Mohammed Suhaimee bin Abd. Manaf, Hanan bin Mohd Yusof and Dr. Ahmad Daud bin Om)

Three researchers from FRI Pulau Sayak, FRI Glami Lemi and FRI Tanjung Demong have collaborated in developing this feed formulation. The idea was generated after discussing with the local farmers regarding the difficulties experienced in producing their own farm-produced pellets conventionally. Commercial pellets in the market are pricey, not environment-friendly, time-consuming to produce and doubtful on its *halal* status. GrowEZmix is an instant premix feed formula

developed to acquire balanced diet for both farmed freshwater and marine aquaculture species. It is affordable, simple and fast to prepare with no additional use of crushing machine or weighing scale. The farmers just need to mix the macro and micro premix first followed by the addition of palm/fish oil and water into the pellet machine.



PrimEZeal (Inventor: Mohammed Suhaimee bin Abd. Manaf, FRI Pulau Sayak)

At present, tiger prawns/giant freshwater prawns are directly fed fresh food such as squid, shellfish and polychaete. However, they are exposed to the risk of disease infections caused by parasites, bacteria and viruses which are present in fresh food. Thus, PrimeEZeal was formulated with a mixture of known fresh ingredients, PrimeEZeal takes a wet sticky-paste form and is prepared by heat sterilization for the maturation of giant prawns, shrimps and marine fish. This formulation is affordable and complies with the biosecurity standards. With this preparation, farmers no longer have to be dependent on fresh feed which may also lead to contamination from pathogens. Formulated with available local ingredients, PrimeEZeal can be stored for a long period. This innovation has been filed with MyIPO for Patent (COF No: PI2017703947) and Trademark (COF No: 2017065860, Class 31)

PrimEZeal™



Maturation Diet Formulation for Kelah, Malaysian Mahseers (Inventor: Hanan bin Mohd Yusof, FRI Glami Lemi)

At present, it is difficult to procure suitable feed to enhance the maturation and spawning performance of Kelah in order to ensure consistent fry supply for the local aquaculture industry. A researcher from FRI Glami Lemi, Negeri Sembilan had come up with this novel formulation of maturation diet which exhibits positive improvement on maturation rate (by 40%) within Kelah broodstock. This evaluation was conducted at FRI Glami Lemi deploying indoor recirculating aquaculture system (RAS) using domesticated Kelah brooders. The invented maturation diet is also relatively economic and produced from halal ARA (arachidonic acid). Imported lab-grade ARA source are expensive and the sources is doubtful (probably not from halal sources). The main ingredient in this diet is bovine liver which acts as an alternative protein to substitute fishmeal and it has the capability to stimulate gonad development.



D) Feed production technology

Single Phase Feed Extruder Machine (Inventors: Mohammed Suhaimee bin Abd. Manaf, Hanan bin Mohd Yusof, Ahmad Daud bin Om, Faizal bin Rahman, Meor Yahaya Razali and Khairil Nor Kamal Umar)

A Single Phase Feed Extruder Machine called the M-SPEX was developed in order to overcome the problem of unavailability of low cost feed extruder machine in the market. Almost all available machines in the market are expensive, incurs high operational cost and deploys a three-phase power point which is more suitable for processing plants. M-SPEX is the first portable extruder machine using a single-phase and capable of producing 100-150 kg/hour. This machine was developed together with the Malaysia Nuclear Agency and is deemed highly beneficial to the local farmers in increasing aquaculture production. This machine could help the farmers in producing their own pellet at home so that they can be certain of the ingredients used and avoid non halal materials.



M-SPEX

R&D Collaboration on Aquafeed

As science becomes more interdisciplinary and resource-intensive, collaboration is becoming the norm. International big science projects are also becoming more common. Collaboration has been a practice at FRI since its establishment in 1957. Besides producing better quality research and innovation, collaboration also enhances researcher's skills in effective communication with their peers from the academia, industry players as well as farmers and other stakeholders. Collaboration if successful could help in improving FRI's visibility at both national and international levels.

In general, for any party to collaborate with FRI, they should start with a formal request to the Senior Director of Research to carry out the collaboration. Preferably the parties should beforehand identify the researcher that they want to work with and the scope of research to collaborate or product to commercialize. The next step will be invitation from the FRI to present the collaboration proposal to the working committee and later to the technical committee for evaluation. Once endorsed by these committees, the proposal will be forwarded to the top management of the Department of Fisheries (DOF) for approval. Once approved, the offer letter will be issued to the partners concerned. The draft of Memorandum of Understanding (MoU) will be prepared and reviewed by both parties to be finalised and endorsed.

Under the 11th Eleventh Malaysia Plan, FRI had received several proposals for collaboration on aquafeed R&D. The proposals are as presented below:

1. The use of natural rubber serum protein in White Shrimp (*Litopenaeus vannamei*) Feed by Malaysia Rubber Board or Lembaga Getah Malaysia (LGM)

The idea of this collaboration was initiated in 2017. Excess production of rubber serum from the industry in Malaysia is considered as waste. Evaluation by LGM showed that the serum contains a significant amount of protein in it. LGM is in the process of developing a plant capable of producing powdered rubber serum. Hence this project was proposed to evaluate whether the natural rubber serum protein or serum getah asli (SGA) could be incorporated into fish feed as partial fish meal replacement and its effect on fish/shrimps growth. A few meetings have been convened. This project was endorsed by the top management of DOF and LGM. For a start, FRI had suggested to do a feeding trial. This is important to evaluate the acceptance of SGA incorporated fish or shrimp feed and their digestibility before proceeding to the next phase i.e formulation of fish/shrimp feed using SGA to partially replace fish meal. The project is still pending due to the unavailability of sufficient SGA protein for feeding trial.

2. Application of feather meal-based feed (Hi-Profeed) for fish and shrimp by Bio Metro Fusion Sdn. Bhd.

Hi-Profeed is a feather meal-based feed innovated by Bio Metro Fusion Sdn. Bhd. This innovation could lessen the dependency on imported feed and provide cost-effective formulas. High protein and digestive content resulting from the 'waste' material (feathers) can contribute to the increase in protein sources. Hi-Profeed contain about 87-90% total crude protein. At a production rate of 2 tonnes/day, an estimated 100 tonnes can be produced in a month. Preliminary study on its characteristics and suitability as aquafeed had been carried out together with MARDI. Preliminary findings indicated that

3. Use of Azolla in fish feed by Redchem Envirotech Sdn. Bhd.

Redchem Envirotech Sdn. Bhd, Tikam Batu, Kedah had approached En. Suhaimie Abd. Manaf from FRI Pulau Sayak on 3rd July, 2018 to collaborate on fish feed project using Azolla (*Azolla filiculoides*). Dry Azolla was to be used as the alternative protein in fish feed to reduce the cost of pellet production. Azolla was chosen as it multiplies rapidly and in addition it contains high protein level, natural vitamins and minerals. The use of Azolla could reduce the dependency on imported fishmeal. It is widely used as an alternative feed in livestock such as ruminants and chickens feedlots.

At present, the researcher will help the company to formulate the feed. The resulting feed formulation will be tested for its efficacy and if it is effective and economical.

4. Commercialisation of EcoCim Feed by Amo Biotech Sdn. Bhd.

Amo Biotech Sdn. Bhd. (ABSB) is a subsidiary of the FY Group of Company, which operates livestock feedstuffs and chicken slaughterhouse processing. ABSB is supported by one of the major subsidiaries of FY Sdn. Bhd. which produces chicken products under the brand name "AYAMADU". The company has a chicken feed processing factory with a production capacity of 50 MT per day. Since Malaysia is one of the largest broiler producers, sufficient supply of chicken intestine can be procured for this collaborative work. Realising the issue of increasing cost of fishmeal in the market, Amo Biotech Sdn. Bhd. is keen to cooperate with FRI. The company is interested to commercialize eco-friendly and economical patented fish feed formulation -EcoCIM Feed by FRI Glami Lemi. DOF had set the technology licensing fee of RM 50,000 which was agreed by both the parties.

There were also a few proposal from other international companies based in Malaysia which are still at planning stage. FRI also hopes to see growing partnerships with their counterparts abroad, which can increase research outputs in RMK 12. FRI hope to broaden its research scope and be more open, making FRI an ideal centre for collaboration for fisheries researchers in the country and around the world.



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Hi-Profeed contain high protein digestibility in tilapia (99%) and shrimp (90%). Hence, Bio Metro Fusion expressed their interest in carrying out research using Hi-Profeed in fish and shrimp feed formulation. For a start FRI and BioMetro Fusion agreed to conduct a feeding trial before proceeding with MoU preparation. A small scale feeding trial is being planned and based on the outcome, the proposed project will be forwarded to the top management for collaboration approval.



Centre in the News



April 7th 2019: The Director General of Fisheries, Dato' Hj. Munir bin Hj. Mohd Nawi briefed the Malaysian Prime Minister YAB Tun Dr Mahathir Mohamad on the development of fishery activities in Pulau Layang-Layang in a closed meeting held in Magellan Sutura Harbor Resort in Kota Kinabalu. The meeting was also attended by the Malaysian Armed Forces and the National Security Council. The briefing emphasized on the empowerment of key activities in Pulau Layang-Layang which had contributed to Malaysia's economy and sovereignty, including the development of the National Coral Centre and Tuna Culture in semi-submersible cages.



During the event, Dato' Munir also submitted two books titled; Layang Layang : A Drop In The Ocean and Marine Biodiversity of Layang Layang to the Prime Minister. The Prime Minister encouraged the Department of Fisheries to expand and intensify fisheries research in Pulau Layang-Layang. Dato' Munir welcomed Tun Mahathir's suggestion and agreed to intensify fisheries development & research activities by involving NGOs and universities in this strategic partnership.



12th March 2019: Hari Bertemu Pelanggan held at FRI Batu Maung Penang. The event was officially launched by the Minister of the Agriculture and Agro-based Industries. Among the activities carried out were exhibition from departments and agencies under the MOA, R&D products exhibits, selling of agricultured products, exchange of MOU and agreement for commercialisation and dialogue between the MOA and stakeholders.





Jan-Feb 2019: Training on fisheries resources survey using research vessel, KK Senangin II is an annual program conducted by FRI Kampung Acheh, Sitiawan. Two resource surveys using basic trawl were conducted in 2019. The first trip was conducted on 29 to 31 January 2019 whereas the second trip was conducted on 26 to 28 February 2019. These resource surveys aim to investigate the resource status of composition species, to collect sample for squid fecundity studies and DNA barcoding studies and also collecting samples for larvae study. Besides, these surveys also provide a viable training opportunity to newly appointed researchers. These voyage training and resource surveys covered area in vicinity of Pangkor Island and Sembilan Island waters. These resource surveys were led by Tuan Haji Samsudin bin Basir and participated by two research officers; Ms Noor Hanis Abu Halim and Ms Nur Hidayah Asgnari, three assistant research officers; Mr. Sai'fulhak Yahaya, Mr. Nazir Taib and Mrs. Zulifah Rohani and were assisted by 15 fisheries vessel crew members.

Fish sorting according to species



Weight and length measurement of each fishes to obtain biological data



Sampling of larvae was conducted by using larva net



2nd May 2019: FRI Batu Maung and AkuaTAR received an official visit from participants of International Atomic Energy Agency (IAEA) Regional Workshop. The workshop was conducted for five days, from 29th April to 3rd May and attended by participants from Malaysia and 14 other foreign countries. The objective of the workshop was to highlight, review, and discuss issues related to the implementation of Quality Assurance and Quality Control activities for proper implementation and performing nuclear spectrometry techniques, including addressing recommendations for compliance to ISO17025. The workshop included lectures, group activities, and technical visits to laboratories in Penang, expecting participants from each country to grasp good understanding of how a quality management system works, to validate their results and to apply the experience and knowledge gained in their laboratories.