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Shariah Compliance Practice for Aquaculture Application: Development of Sustainable Fish Pellet from Food Waste

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Abstract: This paper reported on the development of a new formulated fish feed pellet prepared by an extrusion method and the effect towards water quality according to Shariah compliance practice. The obtained pellets showed an excellent combination of all ingredients using household waste such as fish waste, sugarcane fiber waste, chicken fats and used palm oil. As a result, the well-developed feed pellets exhibit a remarkable improvement in preserving water quality compared to commercialize fish feed pellet. The new formulated fish feed pellet has low turbidity value and Biochemical Oxygen Demand (BOD) level, which help in maintaining the quality of water. It was found that the new pellet may slightly reduce the pH of the water at the low composition of protein sources.

Keywords: Shariah compliance, aquaculture, fish feed, food waste, sustainable management

1. Introduction

The aquaculture industry has been drastically increasing due to high demand from various industry, mainly in the food and cosmetic industry. Fish may be cultured in ponds, raceways, net cages or even in the tank in order to meet these industrial demands. Despite the high demand for aquaculture products, these have a lead concern on environmental issues mainly on water quality and eutrophication, especially fish culturing in water sources (Wu *et al.*, 1994; García-Poza *et al.*, 2020). The production of fish, especially using marine aquaculture sites lead to an increase in amounts of effluent including nutrients, waste feed, feces as well as medications and pesticides (Wu, 1995; Hayashi *et al.*, 2010; Taelman, 2016). Several factors contribute to these problems, and it depends on culture method, species, stocking density, the hydrography of the site, husbandry practices as well as feed type (Carroll *et al.*, 2003; Irungu *et al.*, 2018). Generally, fish feed is essential to ensure the growth of fish, but due to highly dependent on chemicals to preserve the taste and nutrients in the formulation have led to environmental problems. On top of that, some selection of the formulation could be harmful to the ecosystems.

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In Malaysia, fish are typically fed with trash feed, formulated feed, poultry industry waste and the by-product of agriculture production due to costing issues (Yamashita *et al.*, 2009; Bhaskar *et al.*, 2015). However, these types of feeds lack proteins, vitamins and other supplements which will not provide better growth and digestibility of the fish (Karakassis *et al*., 2002; Barrows, Lipman, & Bailey., 2003; Craig *et al.*, 2017). Besides, some of the fish feed is not able to be fully digested by the fish and could end up settling down at the bottom of the tank (Barua & Chakraborty, 2011; Blaszczyk, Augustyniak, & Skolimowski, 2013). Besides, studies showed that some phosphorus, carbon and nitrogen from feed might be lost into the environment through fish excretion, feed wastage, faeces production and respiration (Irungu *et al.*, 2018). The environmental impact of dissolved nutrient and constituents depend on the rate assimilation of the product by the ecosystem. However, there is a risk of high levels of nutrients accumulation which could cause hyper nitrification, high sediment oxygen demand, anoxic sediments, production of toxic gases, and reduction of benthic diversity (Mmochi *et al.*, 2002; Tacon & Metian, 2008; Hasan & New., 2013). Thus, sustainable development of fish feed will help to prevent these potential problems via circumspectly selecting the formulation and conclusively improved properties of the feed.

1.1 Production Method Shariah-Compliant Food Products

Food is a basic need for people. It is needed by humans, animals, plants and other living things for survival (Al-Thoriqi, 1984). The term food can be described as; (1) articles used for food or drink for man or other animals, (2) chewing gum, and (3) articles used for components of any such article (Fortin, 2009). According to Che Wan Jasimah (2001), food diet is the science concerned on nutritional substances or nutrients in the food. The health status of a person will determine his nutritional needs. Therefore, diet is the process of how the body uses the food entirely as a source of nutrients (Radzi, 2001).

In the Islamic perspective, the wise selection of food will help to build a good spiritual and physical condition. According to Imam al-Ghazali (1987), the consumption of halal food will encourage *iman* strengthening and make specific prayers were answered while non-halal (*haram*) food would weaken our beliefs in Islam. As a Muslim consumer, trying to find halal food is decisive action in selecting our daily food. Non-halal and *syubhah* foods are illegal and should be avoided, except when in an emergency.

The connotations concept of halal and *ṭayyib* are synonymous and closely related to each other. Halal means any matter or thing that is allowed by Islamic law (*syarak*). In contrast, non-halal or illegal is any prohibited things. While between both conditions are known as syubhah, which things that preferably avoided. In the treasury of the Al-Quran, Allah SWT clearly said in several times on the importance of choosing halal and *tayyib* foods concepts (refer Surah al-Baqarah: 168, 172, 173; al-Maidah: 1, 3, 4 & 5; al-Nahl: 114). It is clear from these verses, the significance of nutritional aspects emphasized by the Quran. The implications are tremendous in terms of behaviour, psychology, and even in the laws of Islam. Non-halal (illegal) foods can produce wild behaviour and coward. Therefore, the production of food products, must include the criteria of Shariah-compliant (t*ayyib* and *halalan*) as well as needs to be preserved and maintained.

Generally, the production of food products in Malaysia has been increasing from day today. The ability of the food industry in producing various types of food products have catalyzed and shaped the country's economic growth to a level that boasts. Despite the vibrancy of that, consumer, especially Muslims, should be careful in the selection of halal food products and clean (*ṭayyib*) of any element of doubt. The issue arises when the food is being produced from the food waste are reprocessed as fertilizer or forage fish. Based on this, the issue involving the production of food products, particularly concerning halal always happens in the community. The production of food products must adhere to the principles in line with Shariah.

1.2 Responsibilities to Maintain Earth

From the Islamic perspective, it encourages its followers to seek lawful out because God made the earth as a place to find his mercy. Seek lawfully is not possible to claim that one can avoid it (Surah Al-Baqarah: 168). Moreover, God commanded humanity to use all that is in the earth as a source of income for the state and obtain it was lawful. In acquiring livestock blessed by God, the source of animal feed should be of the undoubted source to produce livestock that does not bring discredit on the status of livestock in the future. In pursuit of sustenance, as God commanded, we must ensure that all the activities and events that we run not cause damage to the earth God. God forbid humankind to make mischief in the land because of the improvements that we do will prosper environmental, and God will multiply the things which we obtain (Surah Ali-Imran: 191). This verse clearly shows that the entire contents of this nature are a sign of the greatness and power of God SWT. For those who believe and do right, we should be aware and always try to make the environment clean and protected in all circumstances.

Therefore, the responsibility as a Muslim to strive to improve gaps that exist in a particular activity. In this study, the production process of fish food pallets was developed using household waste for fish farming using the extrusion process. The effect of developed food pellet on the water quality will be the main focused in this study. The material used is a material that does not pose a concern in terms of halal poultry products in the future. The extrusion process is a simple process using heat and steam at high temperatures reaching 190-300 ^{o}F (Barua & Chakraborty, 2011). The chicken fat

used to reduce friction when pallets of food through the barrel of the extruder in addition to be a source of energy in fish eaten (Nya & Austin, 2009; Barreto-Curiel, Durazo, & Viana., 2015). To ensure that pallets will produce safer fish meal as suggested by Islam, these pallets through a series of experiments to analyze their impact on water quality.

2. Methodology

2.1 Preparation of Fish Feed Pellet

The household wastes were collected according to nutrients needed and its function to develop the fish feed pellet. The feed pellets were prepared according to Table 1. The ingredients were then cleaned, ground and extruded into pellets. The formulated fish feed pellet prepared was then used to study its effect on the environment by comparing it with commercializing fish feed pellet. The use of the extrusion cooking method to develop the fish pellets potentially eliminates microbial contamination and inactivates enzymes that preserve food safety (Garrido *et al.*, 2016). The operation concepts start with feeding the raw materials into the extruder barrel, and then screwing in the conveyer, producing the food. The food was compressed by positioning the product between barrel and screw flights. Finally, the fish food will be forced out through the restricted opening at the discharge end as a pallet (Bordoloi and Ganguly, 2014). In this study, the extrusion process was conducted under relatively high moisture content (30-35 %), low to fair shear, barrel temperature and temperature <100 °C. With 10-11 %, moisture content cooled and dried; the extruded pellets become glassy and very stable compared to other processing method (Aguilar-Palazuelos, *et al.*, 2012).

Table 1 - Composition of formulated fish pellet (wt%).

No	Fish scrap	Rice water	Treated sugarcane waste	Chicken fat	Used palm oil
1 (control)	100	-	-	-	-
2	90l	3.0	4.0	1.0	2.0
3	80	7.0	10.0	2.0	2.0
4	70	10.0	15.0	3.0	2.0
5	60	15.0	19.0	4.0	2.0
6	50	19.5	23.0	5.5	2.0

2.2 Turbidity Test

The feed pellets were immersed in water with varies duration time of 1h, 2h and 3h. Then, the water from each pellet samples were collected in prepared turbidity bottle. The turbidity was then measured using Hach 21000N laboratory turbidity meter.

2.3 The pH Test

Fish feed contains high composition of nutrients and organic compound. It will release the nutrient and organic contents immediately when immersed in water. In such situation, excess amount of organic contents may result in low pH of water. As for this study, pH test was conducted in water containing commercial and formulated fish feed using Hanna HI5221pH meter.

2.4 Biochemical Oxygen Demand (BOD)

The samples were analysed and conditioned to ensure there are favourable growth conditions for bacteria, which may include adjustment for pH. The sample were then diluted, and the appropriate amount of seed bacteria added. The initial dissolved oxygen content was recorded, and the sample then incubated for 5 days at 20°C. After the 5 days period, the sample was removed from the incubator and the final dissolved oxygen reading was taken. BOD_5 is calculated by using Equation 1.

$$BOD_5 = \frac{[(D_o - D_s) - (BS_o - BS_s)(1/10)]}{(30mL/300mL)} \quad (1)$$

3. Results and Discussion

3.1 Fish Feed Production

The composition ratios in producing fish feed were based on the amount of percentage of fish wastes that was used. The total weight used for all compositions was 500g. Table 2 showed the observation result for each composition that has been produced. At 100% fish wastes composition, it can be observed that more crumble was formed. This composition does not contain any starch that acts as a binding agent, such as rice water, that was used in other compositions. For

composition consists of 90% fish wastes composition shows less formation of crumble and moderate build structure. This composition has been included with a small amount of starch. As for 70 to 50%, fish wastes composition shows a positive result with no crumble was formed well-build structure. In this composition, the amount of starch added was higher compared with 80% to 100% fish wastes composition. Starch added act as a binder for the ingredients, hence less crumble was formed.

Table 2 - Observation of formulated fish pellet.

Composition (Fish scrap wt%)	Observation
100	Very crumble with poor build structure
90	Less crumble with moderate build structure
80	Less crumble with good build structure
70	No crumble with good build structure
60	No crumble with excellent build structure
50	No crumble with excellent build structure

3.2 Turbidity Test

Turbidity is the cloudiness of suspended solids that were invisible to the naked eye. Hence, this test is vital as it verified the quality of water that has been measured in Nephelometric Turbidity Units (NTU). Turbidity does increase with time due to break down of substances resulting from hydrolytic cleavages that release undisclosed particles and change the clarity of the water. Figure 1 showed that, after 3 hours, 80 to 100% formulations and commercialize fish feed pellet have higher turbidity value more than 5.00 NTU. While for a fish feed at 50 to 70% composition showed low turbidity values below 5.00 NTU. The commercialized fish feed contained most synthetic substances that were very harmful to the environment, which is not readily degraded in water. This condition changed the appearance of water into cloudiness. On the other hand, formulated fish feed at particular formulation efficiently degraded when immersed in water due to the natural occurrence of the ingredients used in the formulation. The high value of turbidity in water will trigger the growth of microorganism, such as bacteria and fungus due to the low penetration of light to the bottom level of water bodies (Karakassis *et al.*, 2002). Hence, it will restrain the aquatic life's ability to obtain dissolved oxygen in the water.

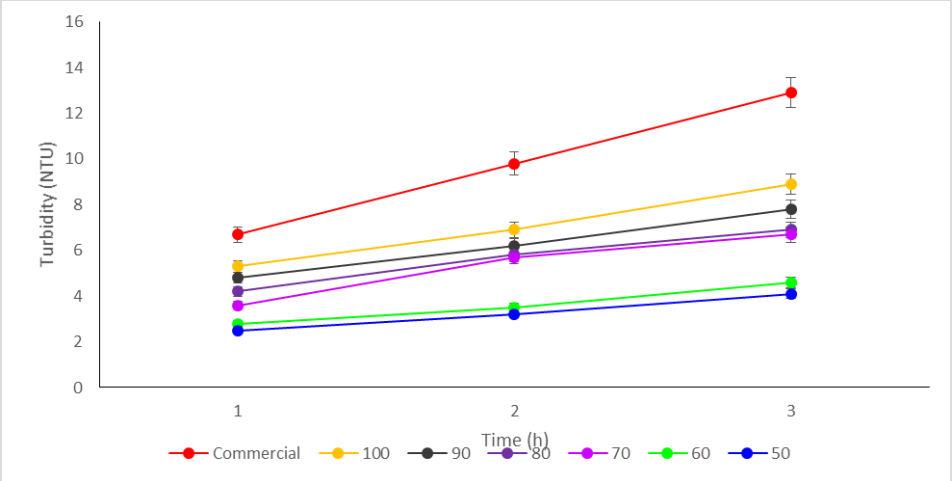

Fig. 1 - NTU level of water after the inclusion of fish pellet.

3.3 The pH Testing

In this test, both types of fish feed show decreasing of pH value after been immersed in water for three hours, as indicated in Figure 2. Commercial and 100% composition shows alkali value slightly, although it has been immersed in water for more than three hours. Commercial fish feed was manufactured mostly by synthetic ingredients that are chemically stable in water for a long duration of time (Irungu *et al.*, 2018). While 100% composition was made up only with one ingredient which was fish wastes only. Therefore, it does not leach any substances that reduced the pH value drastically when immersed in water. As for other compositions, the pH value of water was reduced dramatically into acidic when formulated fish feeds were immersed. This was due to the pressure of other natural ingredients during the production of fish feed, which was added with different ratios into each composition. These ingredients such as oil, chicken skins, sugarcane fibre and rice water were proven to be not chemically stable in water. Hence, when it was immersed in water, the ingredients were leached, since it was not fully bond, which depends on the amount of starch

added as a binder. The formulated fish feed with 100% fish wastes composition showed an alkali characteristic, while other compositions exhibit acidic properties. Overall, the trend shows that the fish feed pellet formulated affect the pH value of water.

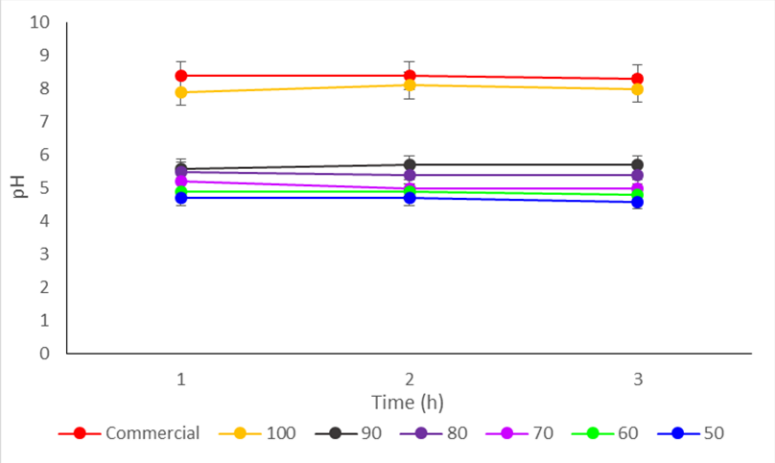

Fig. 2 - The pH value of water after introduced fish pellets.

3.4 Biochemical Oxygen Demand (BOD)

In this experiment, the samples were immersed in water for three hours and seeded with 1mL of microorganisms and were left in the incubator for five days after the dilution and the BOD5 results were calculated for commercial and formulated fish feed as shown in Table 3. Biochemical oxygen demand or commonly known as BOD is a chemical procedure to measure the amount of dissolved oxygen in the water body. The dissolved oxygen (DO) is needed by an aerobic organism such as bacteria as its source of energy to breakdown organic material present in the water body. Biochemical Oxygen Demand is an important water quality parameter because it provides an index to assess the effect discharged wastewater will have on the receiving environment (Barreto-Curiel *et al.*, 2015). If the rate of DO consumption by bacteria exceeds the supply of DO from aquatic plants, algae photosynthesis or diffusing from air, unfavourable conditions occur. Depletion of DO causes stress on aquatic organisms, making the environment unsuitable for life (Tacon & Metian, 2008). As can be seen from the results, DO was depleted drastically after all samples were incubated for five days. However, compositions of 60% showed a tremendous amount of DO losses compared with other compositions. It shows that there is an excellent amount of living microorganisms in the sample. The higher the BOD value, the higher the amount of organic matter available for bacteria life. The consequences of the high BOD are the same as those for low dissolved oxygen: aquatic organisms become stressed, suffocate, and die.

Table 3 - BODs level of commercialize and new formulated fish pellets.

Sample	Initial DO, mg/L	Final DO, mg/L	Depletion DO, mg/L	BOD_5, mg/L
Blank	4.72	4.66	0.06	0.0002
Blank seeded	5.24	3.82	1.42	42.60
Commercial	4.41	1.50	2.91	27.68
50%	4.48	1.04	3.44	32.98
60%	4.58	2.12	2.46	23.18
70%	5.53	2.35	3.18	30.38
80%	5.78	2.54	5.20	30.78
90%	5.97	2.72	3.25	31.11
100%	6.14	2.88	3.26	31.18

Consumers like fish and other aquatic animals eat some of the producers, and the nutrients move up the food chain. When these organisms die, bacteria decompose the organic compounds and release into the water inorganic nutrients such as nitrate, phosphate, calcium, and others. Some of these nutrients end up downstream or in sediments, but most of them recycle again and again (Nya & Austin, 2009). Most of the bacteria in the aquatic water column are aerobic. That means that they use oxygen to perform their metabolic activities of decomposition. On top of that, dissolved oxygen exists in low concentrations. Natural levels of oxygen in aquatic systems are always somewhat depleted by normal levels of aerobic bacterial activity. In most cases, if dissolved oxygen concentrations drop below five parts per million (ppm) or mg/L, fish will be unable to live for very long. All clean water species such as red tilapia will die well above this level.

4. Conclusion

In this paper, newly formulated fish feed pallet was successfully synthesized by the extrusion method. The feed pallets obtained showed excellent integration between all ingredients and had well-defined physical characteristic. The 50% and 60% formulation showed a great combination which suitable for developing new type feed pallet. The effect of formulated fish feed pallet on to water quality has been studied on turbidity, pH and BOD level. The overall trend suggests that the new formulated feed pellet was not given significant effect on water quality compared to commercialize fish feed. The 60% formulation showed low turbidity and BOD level, which can be used for further studies to improve aquaculture system. The optimization studies need to be done in future research works in order to optimize the fish feed pellet production, especially in large scale production.

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