Utilization and benefits of palm oil in fisheries

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Abstract. Utilization of crude palm oil as a fish feed ingredient has been carried out in recent years. Crude palm oil can replace fish oil on dietary fish. The use of CPO has been applied to barramundi (Lates calcarifer), Rainbow Trout (Oncorhynchus mykiss), Japanese sea bass (Lateolabrax japonicas), salmonid species, and Nile tilapia (Oreochromis niloticus) diets. Palm oil appears to boost protein efficiency when being added to oxidized fish feed. The various advantages of palm oil include superior energy sources (saturated and monounsaturated fatty acids), high content of natural antioxidants (carotenes and E vitamin), lessening fatty acid deposition, and low cost and producing high oil yield. Moreover, palm oil-based diets for fish indicated no effect on the fillets either in their texture or color. Fish growth is not disturbed if you change fish oil to crude palm oil in fish feed. The level of use of palm oil is different for each fish species.

1. Introduction
Fish is one of the sources of food needed by humans. Over time, the human population increases, causing the need for fish to also increase. Fish is also a renewable food source, so it is possible to encourage its production every year. Capture fisheries have not been able to meet human needs for fish so other alternatives are needed. One of them is by developing aquaculture.

This aquaculture requires several preparations, namely seeds, land, feed, and labor who will manage it. The fish feed used so far is made from fish oil. In recent years, research on fish feed has been increasing and diversifying. However, to reduce feed costs without compromising quality, these feed ingredients can also be substituted with plant-based ingredients such as rubber seed oil [1], cashew kernel oil [2] or palm oil [3,4] as a source of lipid and nutrients. Soybean is used as raw material and protein source [5].

Palm oil in its use is controversial. The palm oil debate discusses its economic, environmental, health, and social impacts [6,7]. However, palm oil is the most widely consumed and the first source of oil to be widely produced [7] that meaning that the palm oil trade has positive and negative impacts on human well-being [8].

Recently the use of palm oil is preferred because it is relatively cheap and easy to obtain and does not reduce the quality of fish [9,10]. In addition, from 2013 to 2018 there has been an increase in world palm oil production [11]. This is what encourages the utilization of palm oil [12]. Indonesia is also a palm-producing country, so it is very potential to use palm oil as a fish feed mixture. Reciprocal use can also be applied, fishbone waste is also beneficial for the growth of oil palm plants [13].
2. Palm Oil

Palm is a high-level plant that belongs to the Monocotyledoneae group of plants. Palm also belongs to the order Arecales with the genus Elaeis. General characteristics of the palm such as compound leaves with a midrib, fibrous roots, separate male and female flowers, and the fruit is in the form of bunches. This palm fruit that produces palm oil. Several palm oil producing islands in Indonesia such as Riau, Kalimantan, Sumatra, and Bangka Belitung.

The role of oil palm in the global oil trade, particularly in Indonesia, has both positive and negative impacts [14,15], however, it is still under hot discussion at the moment regarding the economic, environmental, health and social impacts of palm oil [16]. Oil palm plantations in Papua can bring wealth and raise living standards, but development in forest areas also loses a lot of value due to the loss of ecosystem services [17]. However, in recent times Malaysia has promoted landscape which heterogeneity to enhance the biodiversity benefits of certified palm oil production [18]. Because the benefits of oil palm are not evenly distributed across rural populations [19]. Likewise, the global palm oil sector must change to save biodiversity and also can increase food security, especially in the tropics area [20]. In addition, the detection of individual oil palms and observation of growth status from UAV images will lead to more precise and efficient management of oil palm plantations [15].

The expansion of oil palm in rural areas in Indonesia has a strong and positive impact on the provision of personal goods (household facilities) although not on the provision of most public goods (public and government facilities used by households) [15]. Although, there are some negative impacts caused by the widespread use of palm oil, on the other hand, the utilization of palm oil provides good benefits for consumers, especially in the food and bioenergy industries.

Palm oil has been used as food and medicine for many years, but the recent utilization of palm oil has been absorbed by the food industry [21]. Malaysia has developed a decision model which can optimize the palm oil biomass value chain [22].

Palm oil possesses biochemical properties due to its high content of palmitic acid and antioxidant. Nevertheless, the unsaturation in sn-2 causes it to function like a monounsaturated oil. It has no effect on blood cholesterol levels than olive and peanut oil, which contain noncholesterol. Moreover, its antioxidant content is beneficial to prevent various ailments [23].

Palm oil has many advantages. However, this palm oil also has some challenges. The challenge in producing clean palm oil lies in the management of palm oil mill waste [24]. Malaysia is currently converting palm oil waste into valuable fuel through biological and thermochemical means [25]. In addition, the use of organic fertilizer from palm oil mill waste (POME) which is treated anaerobically combined with chicken manure can increase plant vegetative growth [20]. Likewise, the synergy of plastic waste and palm oil fuel ash is useful in building construction or concrete drying [26]. In addition, the use of palm oil as a fish feed ingredient has also begun to be widely carried out and this is in synergy with the environment.

3. Palm Oil in Fisheries

The fish feed is the most important part of aquaculture because it is one of the keys to success in aquaculture. There are two kinds of fish feed, namely natural and artificial feed. Natural food is sourced from zooplankton and phytoplankton. Artificial feed is man-made. This fish feed has a composition of protein, lipid acid, carbohydrates, vitamins, minerals. Fish needs for protein range from 20-60%. The protein requirements of carnivorous fish groups ranged from 30-60%. Fish needs for fat ranged from 4-18%. Fish needs for carbohydrates ranged from 20-30%. Carbohydrate sources are usually from vegetables such as corn, rice, bran, wheat flour, sago, and others. Fish needs for vitamins and minerals range from 2-5%. The feed formulation is also different for each fish species, even if it is juvenile or mature fish. This lipid acid source can be obtained from vegetable or animal sources. Animal sources are fish oil. Vegetable sources can use palm oil.

Palm oil in fisheries is used as an ingredient in fish feed mixtures. There are several types of palm oil used in fisheries, such as crude palm oil (cPmO), refined palm oil (rPmO) [27], and Palm Oil Mill Effluent (POME) [28]. In Malaysia, 1 ton of crude palm oil (cPmO) can be produced from 5 to 7.5 tons
of fresh fruit bunches (FFB), with more than half of the water ending up as Palm Oil Mill Effluent (POME).

CPO is a mixture of fishmeal and crude palm oil, while DSO (fishmeal and dried POME sludge) is a mixture of fishmeal and dried POME sludge (Table 1). The growth performance for CPO and DSO has similar values, so it is better to use DSO fishmeal. The utilization of DSO is considered more effective and efficient because, in addition to being fishmeal, it can also reduce pollution due to the waste of palm. The use of palm oil is intended as a source of fatty acids needed by fish.

**Table 1. Growth performance of Nile tilapia fed with CPO and DSO (contained POME) [27]**

| Parameter measured        | CPO          | DSO          |
|---------------------------|--------------|--------------|
| Mean initial weight (g)   | 6.13 ± 0.18  | 5.79 ± 0.15  |
| Mean final weight (g)     | 26.06 ± 0.20 | 25.41 ± 0.09 |
| Weight gain (%)           | 325.12 ± 0.1 | 338.86 ± 0.2 |
| Feed conversion ratio (g) | 3.1 ± 0.26   | 2.48 ± 0.17  |
| Protein efficiency ratio (g)| 1.19 ± 0.02 | 1.13 ± 0.05  |

Environmental issues from palm oil waste have also become a concern lately, so several researchers have conducted research with the use of palm oil that has minimal waste, one of which is the use of DSO (Table 1). DSO is recommended to be used over CPO because the growth performance of *Nile tilapia* and feed utilization of DPO was not much different compared to CPO.

The mean final weight for *Nile tilapia* using CPO was 26.06 ± 0.20g, while the DSO was 25.41 ± 0.09g. The difference is only 0.65g. In the protein efficiency ratio value, *Nile tilapia* using CPO was 1.19 ± 0.02 g while DSO was 1.13 ± 0.05 g. The difference is only 0.06 g. The difference between the two values is not even 1, so it is recommended to use DSO as a mixture of Nile tilapia fish feed. In addition to reducing palm waste, it is also a source of fatty acids and/or protein. Likewise, the weight gain and feed conversion ratio parameters show a small difference.

Crude Palm Oil is also included in the feed of juvenile *Heterobranchus longifilis*. As a result, the addition of Palm Oil to the feed can affect the mineral composition of the whole fish body [10]. The minerals are microminerals and macrominerals. Microminerals such as Fe, Zn, and Mn. Macrominerals such as Ca, P, K, Na, and Mg. Ca and P are very important for the body of fish, Ca plays a role in bone growth and development, muscle contraction, and enzyme activation [29,30]. Phosphorus is the most important mineral because it is not available in the aquatic environment and can only be obtained from feed. Phosphorus deficiency will cause decreased skeletal development and bone deformation [30,31]. Microminerals are needed only in small amounts but have a very important role.

An increase in the levels of palm oil used in the fish feed from 3% to 9% indicates an increase in the content of macrominerals and microminerals throughout the fish body. This indicates that the addition of palm oil to fish feed will modify the mineral composition of the fish body without having a major effect on the health and nutritional quality of fish [10].

Another study applied red palm oil to Japanese sea bass *Lateolabrax japonicus*. The results showed that survival, feed conversion ratio, condition factor, and hematocrit were not affected after 60 days of feeding. Furthermore, when palm oil is given to oxidized fish meals, it increases protein efficiency and positively affects growth performance [4].

Replacement fishmeal from fish oil to palm oil on red sea bream *Pagrus major* is recommended no more than 40% may be a suitable ratio [32]. Different results in Nile tilapia *O. niloticus*. Fish fed the 6% palm oil level recorded the highest level of whole-body docosahexaenoic acid (DHA)[33]. Another case is in the juvenile African catfish *Heterobranchus longifilis*. The 9% level is the most suitable level and the best growth rate and nutrient utilization [34]. On the Indian major carp, *Cirrhinus mrigala*, level 25% is best [35].
Palm oil has various advantages over vegetable oils like soybean or rapeseed oil. Palm oil offers a high oil yield, low cost, low deposition of undesired fatty acids like 18:2(n-6), superior energy source in the form of saturated and monounsaturated fatty acids, and a high level of natural antioxidants (carotenes and vitamin E). Feeding salmon palm oil-based diets had no effect on the texture or color of the fillets. Palm oil also does not have a negative effect on fish growth even at a level of 100% [36]. Palm oil can replace fish oil in fishmeal at Clarias gariepinus fingerlings [37].

Several previous studies have also shown that palm oil has a good effect on growth and feed utilization in O. niloticus [38], C. mrigala [35], H. longifilis [9], Larmichthys crocea [39], and Clarias gariepinus [40].

4. Advantages and Disadvantages of Utilization Palm Oil in Fisheries
Each material used will have advantages and disadvantages. The same goes for this palm oil. Consideration of utilization of lipid acid sources for fish feed is more emphasized on cost and availability in the market. However, it would be wise if the use of a material is not excessive and still pays attention to the risks it has.

Advantages of using palm oil:
- The growth performance of fish using palm oil and fish oil shows no significant difference [3]
- The utilization of palm oil can increase innate immunity in juvenile Nile tilapia O. niloticus [3]
- The muscle protein content of Nile tilapia O. niloticus can be modified when using palm oil-based feed. mRNA expression of Pdx-7 and Capn-3 affected by palm oil [41]
- The fish growth, survival, and feed pada Heterobranchus longifilis more efficient [42]
- Palm oil can enhance feed efficiency, protein utilization, reproductive success, and -tocopherol concentrations in fish fillets [12]

Disadvantages of using palm oil:
- Previous research found that when comparing palm oil with cashew kernel oil. The costs incurred for feed are still cheaper by using cashew kernel oil as fish feed material. The growth performance in Clarias gariepinus fingerling is low when compared to using fish oil or cashew kernel oil [2]
- The utilization of palm oil with high concentrations (75% and 100%) can be at risk of causing liver damage in fish [3]

5. Conclusion
Palm oil and palm oil mill waste has been used in various fields, especially in the food industry, medicine, and other industries. The utilization of crude palm oil as fish feed material has been carried out in recent years. Crude palm oil can replace fish oil in fish feed. The use of CPO for fish diet has been applied to barramundi (Lates calcarifer), Rainbow Trout (Oncorhynchus mykiss), Japanese sea bass (Lateolabrax japonicas), salmonid species, and tilapia (Oreochromis niloticus). The overuse of palm oil, surely, has negative impacts. However, it also is beneficial in terms of high oil yield, low cost, reduced heat deposition of undesirable fatty acids, superior energy source (saturated and single unsaturated fatty acids), and high content of natural antioxidants (carotene and vitamin E).

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