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The potentiality of microalgae as a source of DHA and EPA for aquaculture feed: A review

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Abstract
Microalgae have the various function with positive health effects. For not only human beings, but also its potentiality has important roles for aquaculture system. Microalgae provide the essential fatty acids namely PUFAs. The long-chain polyunsaturated fatty acids (PUFAs) with two most important parts; Docosahexaenoic acid (DHA) and Eicosapentaenoic acid (EPA) is well known for essential nutrition in aquaculture. This review was examined the DHA and EPA function, DHA and EPA contained in microalgae, and value-added microalgae as PUFA fed source in aquaculture. The future directions of microalgae-assisted aquaculture for industrial applications were suggested.

Keywords: Microalgae, Fatty acid, PUFA, EPA, DHA, Fish feed

Introduction
Microalgae are widely used in aquaculture; its function is related to nutrition, and the energy flow through the aquatic grazing food chain [1]. Microalga have the important roles for aquatic animal nutrition, either for direct consumption or for indirect consumption such as a food for live prey, like planktons and small fish [2]. Previous report showed that the growth performance of aquatic animals fed by mix algae species was greater than fed by only one species, it might be due to the small amount of nutrient contained in a single alga and the lack of nutrient can be covered from another alga [3].
Microalgae are commonly used in aquaculture as natural feed sources for the first feeding process of fish larvae [4]. In recent years, the potentiality of microalgae chemicals composition and its application in many cases of waste water treatment have been reviewed recently [5, 6]. Besides that, it plays important role in water quality control, aquaculture feed production, and nutrients recovery, for the sustainable development of the aquaculture industry [7]. This review focused the potentiality of microalgae as a valuable feed source with PUFA components such as DHA and EPA for aquaculture feed. Like human beings, fish attain DHA and EPA from their diet, basically from microalgae.

Microalgae as an additive feeding in aquaculture
The intensification of intensive aquaculture particularly depends on the supply and suitability of feed. Feed cost represents the highest and the most variable cost of fish production. In order to reduce feed costs, alternative resources from plant are considered as economically and environmentally friendly for feed ingredients. Nowadays, algae are receiving the high utilities in intensive aquaculture due to their high protein content and high production rate [8]. It has been reported that algae containing an effective radical foragers, inhibitors of lipid peroxidation and enhancing the immune response and disease resistance [9]. Several studies using microalgae such as *Spirulina sp.* were conducted with the following species- *O. niloticus* [10], *Oncorhynchus mykiss* [11]. Some species also utilized as live feeds for molluscs (oysters, scallops, clams and mussels), for first feeding of abalone, crustaceans, some fish species, and for grazing food chain in aquaculture[12], *Isochrysis* sp., *Pavlove lutheri, Chaetoceros calcitrans* are the common microalgae used in aquaculture feeding sources (Table 1).

Table 1: Microalgae commonly used in aquaculture for Molluscs, Crustacean larva, juvenile abalone, and zooplankton

Species	Molluscs	Crustacean larvae	Juvenile Abalone	Zooplankton
Isochrysis sp.	✓	✓		✓
Pavlova lutheri	✓	✓		✓
Chaetoceros calcitrans	✓	✓		✓
C. Gracilis	✓	✓		✓
Skeletonema spp.	✓	✓		
Tetraselmis suecica	✓	✓		✓
Rhodomonas spp.	✓			
Pyramimonas spp.	✓			
Navicula spp.	✓	✓	✓	
Nitzschia spp.		✓	✓	
Cocconeis spp.			✓	
Amphora spp.			✓	
Nannochloropsis spp.				✓

Adopted from Brown (2002)

DHA and EPA Function

DHA (Docosahexaenoic acid) and EPA (eicosapentaenoic acid) are Omega-3 [(n-3)] long-chain polyunsaturated fatty acid which important for human health. DHA accumulate in the human brain and important for a membrane structure in the central nervous system [13]. DHA has been proved that can improve memory and reaction time of young adults [14], important for fetus brain development during pregnancy, increase infant problem solving [15], increase visual acuity of infants and can affect neurological function [16]. EPA also has important role for human health. EPA can use to prevent coronary heart disease, reduces platelet activation, an early step in platelet aggregation and reduced systolic blood pressure [17]. Combination of EPA and DHA can and decreased incidence of asthma in the children [18].

DHA and EPA in Microalgae

One feed source in aquaculture that contains DHA and EPA is microalgae. Some species of microalgae that contain EPA and DHA are *Spirulina platensis*, *Chlorella vulgaris*, *Storeatula major*, *Chroomonas mesostigmatica*, *Guillardia theta*, *Hemiselmis* sp, *Proteomonas sulcate*, *Rhodomonas salina* [19]. The commercially produced microalgae, *Spirulina platensis* and *Chlorella vulgaris* are widely consumed by human. They can be used as alternative sources of DHA and EPA. DHA and EPA content in *Spirulina platensis* are 72,345 mg/g and 331.07 mg/g dry weight, while the DHA and EPA content in *Chlorella vulgaris* are 36.53 and 123.46 mg/g dry weight. The concentration of DHA and EPA in *Spirulina platensis* was higher than *Chlorella vulgaris* [20].

EPA is rich in algae such as diatoms, *eustigmatophytes*, *prymnesiophytes*, and *cryptomonads*, besides that, DHA are usually limited to the *dinoflagellates* and some marine heterotrophs [21].

Nutrition values of microalgae

The screening of nutritional values of microalgae is needed to support its function for aquaculture purpose. Therefore, the potential algal with recommendation could be examined. There are some algae species with great potential to be used for feeding in aquaculture based on its nutritional values. The nutritional value components in microalgae could be classified into several categories. First, microalgae with rich in protein and carbohydrate can be used to replace the conventional feed. Second, microalgae with rich of antioxidants can be used to enhance the immune system of aquatic animals. Third, some components play important roles in the growth of special fish such as DHA and EPA [7]. Table 2. Listed the nutritional values for some potential microalgae for aquaculture feeding with containing DHA and EPA.

Table 2: The lipid contents and value –added compound of microalgae

Species	*Lipid (%)*	*Value-added Compound*	*Reference*
Thraustochytrium sp.	38.95	DHA and EPA (37.88% of total lipid)	[22]
Chlorella zofingiensis	30-50	PUFA (36.89–49.16% of fatty acid profile)	[23]
Scenedesmus sp.	33.4	EPA (15.89% of fatty acid profile)	[24]
Chroomonas mesostigmatica	N/A	DHA and EPA (15.8% of total lipid)	[19]
Proteomonas sulcata	N/A	DHA and EPA (20.4% of total lipid)	[19]
Teleaulax acuta	N/A	DHA and EPA (32.1% of total lipid)	[19]
Teleaulax amphioxeia	N/A	DHA and EPA (28.9% of total lipid)	[19]

Conclusion

Based on the value-added of microalgae such rich of DHA and EPA, this review shows the potentiality of microalgae as an aquaculture feed. In recent years, technologies have been widely developed to promote the application of microalgae-fed based aquaculture, include examination of beneficial effects of microalgae on aquatic animals. Even though microalgae are potentially very promising sources for aquaculture, the present challenge is to find an economically and commercially ways for mass production, and searching for the most suitable species/strains plays an important role in aquaculture feeding.

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