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# Microencapsulation of biological compounds for cultured fish diet. A brief review

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***Abstract***

Fishes require different types of live diet for their better growth, efficient breeding and survival. The live diets (live foods organisms) contain all the nutrients, such as: proteins, lipids, carbohydrates, vitamins, minerals, aminoacids and fatty acids. These diets are costly to produce, variable in quality and constitute a potential source of contamination with viruses and pathogenic bacteria. In recent years, a lot of effort has been made to developing the microencapsulated diets for cultured fish species. The microencapsulated diets for fish are highly complex as the microparticles must contain proteins, lipids, carbohydrates, vitamins and electrolytes. This review reports some aspects about several biological compounds that are suitable for microencapsulated fish diets. The development of the microencapsulated diets for cultured fish species is a relevant topic due to the economic impact of aquaculture.

***Keywords***: Aquaculture, Microencapsulation, Biological compounds

## 1.Introduction

In cultured fish, the nutrition with live feed has major drawbacks due to limited possibilities in delivering live feed, high cost to produce live feed and its variable quality [1-3]. To promote the fish farming, the researchers developed novel fish feeds. The development of new diet formulations is a relevant topic, both from an economical and environmental point of view [4, 5]. Various techniques have been developed to produce new diet formulations, such as: pelletization [6-18] and *microencapsulation* (*M*) [3, 5, 19, 20, 21, 22-27]. *M* have been used for the incorporation of proteins, lipids, carbohydrates, vitamins, minerals, hormones, enzymes, antioxidants and probiotics necessary for the growth and health of fishes [28-31]. *M* offers many advantages, such as: compounds can be incorporated at sizes suitable for ingestion, compounds can be preserved for long periods in the microcapsules, and the nutrients are protected and are released by digestive processes and become available for digestion and absorption [32].

The aim of this contribution is to review the literature covering some aspects on some biological ingredients that are suitable for microencapsulated fish diets.

## 2.Proteins

Proteins are essential dietary components for carnivorous and desirable *protein sources* (*P*) for omnivorous fish. Different proteins extracted from animal (albumin, casein, fish protein hydrolysates) have been used as *P* and as material for *M* of different compounds [22, 24, 33-38]. Over the past few decades, the plant-based *P* have been receiving considerable attention as a partial or even complete replacement for fishmeal in aquafeed. Different proteins extracted from vegetables (cottonseed and soybean proteins, soy lecithin, potato protein

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concentrate, barley protein [7, 22, 26, 39-42]) have been used. Some plant *P* possess most of the desirable characteristics. However, there are limits to use of plant *P* in fish feeds, due to high levels of structural fibre, anti-nutritional factors, low digestibility, low palatability, or imbalanced in essential amino acids that may negatively affect the physiology of fish [38, 40, 43].

Researchers are currently investigating the potential for protein from yeast, insects and *Silkworm pupae* [42, 44]. *Silkworm pupae* could replace of the protein from fishmeal in formulated diets for the snakeskin gourami and common carp [42].

## 3.Lipids

Different fish species are dependent on fish oil as a major dietary *lipid source* (*L*) [15]. Nowadays, it is crucial to continue exploring different sources of oils as alternative lipids to support the expansion of sustainable *aquaculture (A)* [15, 45]. Some vegetable oils coming from plant seeds (linseed, rapeseed, soybean, sunflower), palm and olive oils are considered a good alternative *L* used by the aquafeed [15, 46, 47]. However, there are limits to use of plant oil sources in fish feeds because most vegetable oils are relatively poor sources of n-3 fatty acids [48]. Exceptions to this are oils from linseed and canola which are rich in alpha linolenic acid [48]. The partial replacement of fish oil by vegetable oils would be possible when the fatty acids are present in the diets in sufficient quantities to meet their essential fatty acid requirements [45]. There is also an important interest in using of microbial oils [49] and *Silkworm pupae* oil [50] as fatty acids source. In addition, the stability of microbial oils can be more controllable than that of fish oils [49, 51]. The fatty acids from different sources (fish, vegetables, microbial oils) are extremely susceptible to oxidative deterioration. The oxidative stability of n-3 fatty acids is significantly enhanced after *M*. In the area of n-3 fatty acids, the *M* is an important strategy that has been used to stabilize the deliver bioactive and to protect n-3 fatty acids after they have been isolated from their source [50].

## 4. Carbohydrates

The *carbohydrates* (*C*) may be regarded as non-essential dietary nutrients for fish, but their inclusion in fish diets is warranted because they are an inexpensive source of valuable dietary energy for noncarnivorous fish, they can spare the more valuable protein for growth instead of energy provision and they serve as good materials for *M*. *C* have been applied together with proteins and lipids as materials for *M* of biological substances [32, 52]. The *C* that have been used as wall materials for *M* are pectins, starch, chitosan, maltodextrine, gums and modified cellulose [32, 52-55]. Pectin is an ideal wall material for *M* applications which is used to increase transit time or to obtain site specific delivery of biological ingredients [56, 57]. Due to its relatively lower cost, it can be used as a substitute for expensive wall materials [58]. Starch is used in microencapsulating biological compounds due to its potential to prevent degradation in the upper gastrointestinal tract and to provide prolonged or targeted release [59]. Chitosan and maltodextrine are suitable candidate for use in nutrient release systems in aquaculture, some authors used chitosan to coat the granules consisting of potato starch and other dietary components for feeding larvae of some fish species [32].

## 5.Probiotics and plant extracts

The increasing interest in consuming organic and environmentally friendly food leads to limitation of veterinary antimicrobials in *A*. Some of the solutions are the use of probiotics or plant extracts in the culture of fish [60]. The probiotic is any microbial cell provided via the diet or rearing water that benefits the host fish, fish farmer or fish consumer [61]. Most probiotics used in *A* belong to the genus *Bacillus*, to the photosynthetic bacteria or to the yeast, although other genera or species [62, 63]. In *A*, the probiotic have been shown to have significant possitive points, such as: improvement of growth performance, pathogens inhibition and disease control in *A*, improvement in nutrient digestion and in water quality, increase stress tolerance of the host fish, effect on reproduction of aquatic species [61, 64-65]. In aquaculture, *M* is an available vector of probiotics administration for incorporation and protecting the probiotics into fish meal.

The immobilization of probiotics using *M* technique may improve the survival of probiotics in fish feed, both during processing and storage, and during digestion [66]. Several plant extracts are reported to stimulate appetite and promote weight gain (garlic, pepper, ginger), to exercise immunostimulant (mistletoe), anti-pathogenic (algae, ginseng) and parasites effects (cinnamon, garlic, magnolia bark, almond leaf) [60]. However, the use of plant extracts in *A* is a very recent trend so even if most of the studies show promising results there are only a few research that have analysed the long-term effects on fish physiology [60]. The application of plant extracts, as bioactive fish feed additive may be facilitated by the protection through encapsulation technology.

## 6.Concluding remarks

Over the past few decades, various techniques have been evaluated for their capacity to partially replacement live food in fish nutrition. Microencapsulation technology may be a good alternative to partially or complete replacement of live diets used to culture larvae of different species in aquaculture. This work showed the potential of some proteins, lipids, carbohydrates, probiotics and plant extracts as a microencapsulation material in fish feed systems. These components are having a significant influence on the formulation of fish diets and their microencapsulation offers viable alternatives to the live diets in terms of sanitary and economic impact in the aquaculture sector.

**Compliance with Ethics Requirements.** Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human / or animal subjects (if exist) respect the specific regulation and standards.

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