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Review

Use of plant extracts in fish aquaculture as an alternative to chemotherapy: Current status and future perspectives

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ABSTRACT

Aquaculture is the main source to increase fish supply. Fast development of aquaculture and increasing fish demand lead to intensification of fish culture, magnifying stressors for fish and thus heightening the risk of disease. Until now, chemotherapy has been widely used to prevent and treat disease outbreaks, although use of chemical drugs has multiple negative impacts on environment and human health e.g. resistant bacterial strains and residual accumulation in tissue. Hence, disease management in aquaculture should concentrate on environmentally friendly and lasting methods. Recently, increasing attention is being paid to the use of plant products for disease control in aquaculture as an alternative to chemical treatments. Plant products have been reported to stimulate appetite and promote weight gain, to act as immunostimulant and to have antibacterial and anti-parasitic (virus, protozoans, monogeneans) properties in fish and shellfish aquaculture due to active molecules such as alkaloids, terpenoids, saponins and flavonoids. However, as it is a relatively emerging practice there is still little knowledge on the long-term effects of plant extracts on fish physiology as well as a lack of homogenization in the extract preparation and fish administration of the plant extracts. This article aims to review the studies carried out on the use of plant products on fish aquaculture and their biological effects on fish such as growth promoter, immunostimulant, antibacterial and anti-parasitic. It also intends to evaluate the current state of the art, the methods used and the problems encountered in their application to the aquaculture industry.

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1. Introduction

Fish and fishery products represent a very valuable source of protein and essential micronutrients for balanced nutrition and good health. In 2009, fish accounted for 17% of the world population intake of animal protein and 6.5% of all protein consumed. World fish food supply has

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grown considerably in the last five decades, with an average growth rate of 3% per year in the period 1961–2009. Since fish capture has remained stable at about 90 million tonnes since 1990, aquaculture has been revealed as the main source for increasing fish supply. World aquaculture production reached 62 million tonnes in 2011 (excluding seaweeds and non-food products), with an estimated value of US$ 130 billion. Aquaculture is the fastest-growing animal food producing sector with an average annual increase of 6% per year in the period 1990–2010 (FAO, 2012).

However, world aquaculture production is vulnerable and an increase of disease outbreaks has been reported due to culture intensification, resulting in partial or total loss of production (Bondad-Reantaso et al., 2005). Factors such as overcrowding, periodic handling, high or sudden changes in temperature, poor water quality and poor nutritional status contribute to physiological changes in fish such as stress or immunosuppression and thus, heighten susceptibility to infection. Moreover, high concentrations of fish and lack of sanitary barriers facilitate the spread of pathogens, producing high mortality levels (Cabello, 2006; Naylor et al., 2000; Quesada et al., 2013).

In order to avoid economic losses related to sanitary shortcomings, several veterinary drugs are commonly used in aquaculture to prevent or treat disease outbreaks. Antimicrobials and other veterinary drugs are administered regularly as additives in fish food or sometimes in baths and injections and are used as prophylactics (prevent diseases before they occur), therapeutics (treat sick animals) or growth promoters (Rico et al., 2013).

Nevertheless, the use of veterinary drugs is becoming more restricted since they present numerous side-effects for the environment and health safety. For example, massive use of antibiotics have resulted in the development of resistant bacteria strains (e.g. Mirand and Zemelman, 2002; Seyfried et al., 2010) or the presence of residual antibiotics in the muscle of commercialized fish and thus has potential consequences on human health (e.g. Cabello, 2006; Romero Ormazábal et al., 2012). The use of drugs like trichlorfon or praziquantel in bath treatments for ectoparasites has also numerous disadvantages like development of resistance (Umeda et al., 2006), being hazardous for animal health (Forwood et al., 2013; Kiemer and Black, 1997) and environmental disadvantages. Vaccination has also been regarded as a potential treatment against disease outbreaks in aquaculture. However, commercial vaccines are too expensive for widespread use by fish producers and they have the downside that a single vaccine is effective against only one type of pathogens (Harikrishnan et al., 2011a; Pasnik et al., 2005; Sakai, 1999).

Considering the potential harm of veterinary drug treatments on the environment and human health and in some cases their limited efficacy, disease management should concentrate on harmless, preventive and lasting methods. Moreover, disease outbreaks are frequently associated with fish fitness and health, most pathogens being opportunistic and taking advantage of immunocompromised or stressed fish, thus alternate solutions should maximize fish immunity and fitness to avoid and face pathogen infections (e.g., Ashley, 2007; Davis et al., 2002; Iguchi et al., 2003; Ruane et al., 1999). Some of the proposed solutions are the use of natural products (plant extracts) or probiotics (beneficial microbial strains) in the culture of fish and shrimp (e.g., Citarasu, 2010; Lee et al., 2009; Makkar et al., 2007; Mohapatra et al., 2013; Panigrahi and Azad, 2007). Finally, there is an increasing interest in consuming organic and environmentally friendly food. Thereafter, the limitation of chemical products in aquaculture and the use of natural treatments could enhance the consumption of aquaculture products.

In this article we aim to review the potential of plant extracts as a sustainable and effective substitute for chemical treatments in fish aquaculture. In order to be as exhaustive as possible we performed several database cross searches with the keywords “plant extracts” and we found 115 results that matched our criteria. The results clearly show that there is an increasing number of published studies highlighting the potential application of natural products and plant extracts in aquaculture either as immunostimulant or to fight parasite diseases (Fig. 1).

2. Potential of plant extracts in aquaculture

Plant extracts have been reported to favor various activities like antistress, growth promotion, appetite stimulation, enhancement of tonicity and immunostimulation, maturation of culture species, aphrodisiac and anti pathogen properties in fish and shrimp aquaculture due to active principles such as alkaloids, terpenoids, tannins, saponins, glycosides, flavonoids, phenolics, steroids or essential oils (Chakraborty and Hancz, 2011; Citarasu, 2010). Besides, their use could reduce costs of treatment and be more environmentally friendly as they tend to be more biodegradable than synthetic molecules and they are less likely to produce drug resistance in parasites due to the high diversity of plant extract molecules (Blumenthal et al., 2000; Logambal et al., 2000; Olusola et al., 2013).

2.1. Plant extracts as appetite stimulators and growth promoters

Several plant extracts are reported to stimulate appetite and promote weight gain when they are administered to cultured fish (Harikrishnan et al., 2012a; Pavaraj et al., 2011; Takaoka et al., 2011) (Table 1). Shalaby et al. (2006) showed that food intake, specific growth rate and final weight of Nile tilapia (*Oreochromis niloticus*) increased when garlic was incorporated in the diet. In another study, grouper *Ephinephelus tauvina* fed with a diet supplemented with a mixture of methanolic herb extracts (Bermuda grass (*Cynodon dactylon*), Long pepper (*Piper longum*), stonebreaker (*Phyllanthus niruri*), coat buttons (*Tridax procumbens*) and ginger (*Zingiber officinalis*)) displayed 41% higher weight than fish fed with the control (Punitha et al., 2008). Ji et al. (2007a) showed that olive flounder (*Paralichthys olivaceus*) fed with a herbal mixture of medicated leaven (*Massa medicata fermentata*), hawthorne (*Crataegi fructus*), virgate wormwood (*Artemisia capillaris*) and *Cnidium officiale* (2:2:1:1) had higher weight gain than the control fish and showed higher total carcass unsaturated fatty acid content and lower carcass saturated fatty acid content, indicating that feeding with the herbal mixture improves fatty acid utilization. The authors suggested that this could be caused by a lower plasma triglyceride and high plasma HDL-CHO (high-density lipoprotein cholesterol) levels in the herbal mixture diets.

Besides, plant extracts have been shown to improve digestibility and availability of nutrients resulting in an increase in feed conversion and leading to a higher protein synthesis (Citarasu, 2010; Nya and Austin, 2009b; Talpur et al., 2013). For example, Putra et al. (2013) showed that supplemented diet with 1% of ethanolic katuk extract (*Sauropus androgynous*) stimulated appetite, growth and improved food utilization

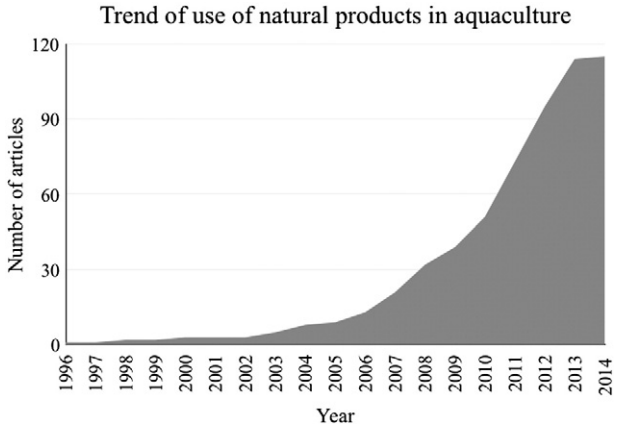

Fig. 1. Number of published articles about the use of plant, algae or natural products in aquaculture.