

Significance of Some Phytochemicals in Aquaculture

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Abstract

Aquaculture has continued to experience more demands globally due to upsurge in population over the years. But the challenge of the use of synthetic chemicals as growth, nutrient booster, and disease prevention and control measures has been the constraint. The need for antiviral, anticancer, growth-promoting, antibiotic, antioxidant, immune-stimulating, and anti-inflammatory ability; coupled with increased disease resistance, growth of aquatic organisms and feed efficiency has brought about the use of phytochemicals as natural, non-antibiotic agent in aquaculture productions. As phytochemicals are natural products, they are considered to be safe for fish, humans, and the environment. In this paper, we reviewed the significance of phytochemicals in aquaculture, their uses, health benefits, their advantages and possible mode of application.

Keywords: *Phytochemicals; Aquaculture; Aquatic organisms; Significance*

Introduction

Aquaculture has remained to be one of the fastest growing food-producing sectors having the highest potential to assist in meeting both marine and inland capture fisheries global demand for aquatic food (FAO, 2016). According to the Food and Agriculture Organization of the United Nations (FAO, 2007), 47% of global finfish stocks are fully exploited, thus offering no reasonable expectations of further expansion, and another 18% are reported as over exploited. Aquaculture has become an important industry and the world's fastest-growing agricultural business sector and is an important commercial activity in many countries (Karga et al., 2020). Global aquaculture production has increased vastly in the last years for the protein requirement of humans (Salem et al., 2021).

Chemical compounds classified as phytochemicals (isoflavonoids, flavonoids and lignans among others) are natural steroid-like compounds derived from soy, tea, fruits and vegetables with a reported aromatase inhibition ability that are able to suppress estrogen biosynthesis in cells (Eng et al., 2001). And phytochemicals have continued to attract attention due to their great health benefits. Phytochemicals are, in simple terms, bioactive compounds of plant origin (Lillehoj et al., 2018), which exhibit a wide array of beneficial effects such as antiviral, anticancer, growth-promoting, antibiotic, antioxidant, immune-stimulating, and anti-inflammatory effects (Terzi et al., 2021).

Farmers forcibly come to the situation to protect and keep the aquatic animals healthier by using different practices, but their prolonged usage of chemicals and antibiotics has created residual

effects and makes pathogens get resistant to the treatments. To overcome antibiotic and chemical residual effects, the alternative resource and solution are industrially important phytochemicals that have fulfilled the needs. Phytochemicals also called to as phyto-biotics or phyto-genics. Phytochemicals are chemical substance that is naturally found in the plant, plant-based nutritional components are a more complex mixture of bioactive components, which are beneficial to the human as well as animals. The objective of this paper is to review the significance of some phytochemicals in aquaculture. However, this review will focus on a few of them.

Examples of some Phytochemicals

Alkaloids

Alkaloids are heterocyclic organic compounds of plant origin, normally with basic chemical properties and containing nitrogen in a negative oxidation state (Hesse, 2002). Many alkaloids exhibit marked pharmacological activity, and have physiological effects that render them valuable as medicines.

Phenol

Phenols are chemical components that occur ubiquitously as natural colour pigments responsible for the colour of fruits and plants (Adeyemi et al., 2014).

Flavonoids

Flavonoids are an important group of polyphenols widely distributed among the plant flora (Kumar et al., 2015). The compounds are derived from parent compounds known as flavans (Faggio et al., 2017). Over 4000 flavonoid compounds are known to exist and some of them are pigments in higher plants.

Tannins

Tannins are phenolic compounds of high molecular weight and they are widely distributed in plants (Zia et al., 2011). Tannins are soluble in water and alcohol and they are mainly found in the root, bark, stem and outer layers of plant tissues (Doughari et al., 2009). They are acidic in solution probably due to the presence of phenolic or carboxylic group (Doughari et al., 2009). Tannins form complexes with proteins, carbohydrates, gelatin and alkaloids thus affecting the functional properties of these compounds (Assefa et al., 2008).

Saponins

The term saponin is derived from *Saponaria vaccaria* (*Quillaja saponaria*), a plant, with abundant saponins and was once used as soap (Aghel et al., 2010). Saponins, therefore possess 'soaplike' behaviour in water, that is, they produce foam.

Steroids

Plant steroids also referred to as 'cardiac glycosides' are one of the most naturally occurring plant phyto-constituents that have found therapeutic applications as arrow poisons or cardiac drugs (Chan et al., 2003). The cardiac glycosides are basically steroids with an inherent ability to afford a very specific and powerful action mainly on the cardiac muscle when administered through injection into man or animal.

Their Uses in Aquaculture

The plant phytochemicals have both nutritional and therapeutic effects. They are not only bioactive components, they also have multi-functional benefits properties to aquaculture as stated below.

As endocrine modifying agent (e.g Flavonoids)

The need for high quality fish seed has necessitated research into various ways of enhancing fertility to meet the growing demand of the populace. Synthetic steroids are commonly used for such manipulation of sex and as enhancers of fertility in fish, but because of their potential hazards the use of phytochemicals is a potential alternative to be explored. The use of medicinal plants as fertility enhancers and sex reversal agents in fish has been receiving some attention. phytochemicals may induce biological responses in fish including oestrogenic effects and reproductive retardance, and hence are sometimes regarded as endocrine disrupting chemicals (EDCs) (Cheshenko et al. 2008). Flavonoids have been found to act as phytoestrogens since these compounds have structures that are recognized as estrogen mimics by the estrogen receptor. They can compete with endogenous estrogens for binding sites to the estrogen receptor; therefore, they can act as antiestrogens or weak estrogens (Miyahara et al., 2003).

As anti-oxidant

Flavonoids and other phenolic compounds as reviews in the literature by Dixon, 2004 have the anti-oxidant ability, that is they have strong antioxidant capacity, along with the ability to interact with protein phosphorylation, iron chelation, and a series of enzymatic reactions (Boyle et al., 2000). Therefore, special attention should be also given to this subject in respect to the use of phytochemicals in fish nutrition or as endocrine mimics of steroid hormones.

For sex differentiation/manipulation in aquaculture

Manipulation of phenotypic sex in fish farming is generally desirable since one gender, depending on the species, grows faster (Uguz et al., 2003). A lot of research has focused on the understanding

of how these factors can be manipulated in order to optimize the production of fish by means of intensification of aquaculture. And tilapia (Cichlidae) is among the species extremely suitable for aquaculture.

Some health benefits of phytochemicals

Some of the plants and their seeds extracts like Moringa leaves and its seed protect animals from oxidation stress conditions and mineral imbalance from blood, liver and kidney. Phytochemicals components are divided into mainly 3 groups of Phenolics, Terpenes, and alkaloids. Key properties of phytochemicals are immunostimulant, antibacterial, anti-inflammation, antioxidant, detoxification and anti-stress. Through research and technological evaluation, thousands of phytochemicals and their molecules get attention of industrial importance based on their physiological and biological benefits. For example phytochemicals of tannins, vitamin c, vitamin e, polyphenol, and flavonoids are wonderful health benefits. And these benefits are as follows:

Regulate metabolic function

Phytochemicals have the potential of interfering with cellular process to regularize the metabolic function of the aquatic animals. The mechanism of phytochemicals not completely understood, but a general understanding is to damage the pathogen microbes membrane by lipophilic compounds to reduce the pathogen microbes cell growth by DNA damage by stopping protein synthesis. Phytochemicals exhibit a wide spectrum of bacterial effects against gram-positive and gram-negative pathogens by the hydrophobicity property with damage the cellular and leakage the intracellular materials effects against gram-positive microorganism.

Immune system enhancer

Phytochemicals play an important role in modulatory activities of the gut in the early stage of animals like fish fry, and shrimp larva. It improves the gut nature by increasing the glutathione in the intestinal epithelial cell. Phytochemicals of flavonoids, polyphenols not only stimulate the immune system and also functions as a detoxifying cation and scavenger of the free radicals and protect and enhance the vital organs which are involved in the immune functions.

Enhance fish productivity

Phytochemicals enhance animal productivity and reduce the disease outbreak and environmental pollutions. There is a need to avoid antibiotics due to residual effects as well as pathogen resistance against antibiotics, but at the same time, productivity cannot

be compromised, because of increasing population and aquatic food demand. The phytochemicals have a potential mechanism on the animal system that will increase the food conversion ratio (FCR), food intake, optimize the gut function, reduce the gut stress due to the pathogen, improve the digestion, immune boost-up, antioxidant and antimicrobial. One big advantage of phytochemicals functions as antimicrobial is without the possibility of the development of resistance and also safe to aquatic animals and humans as well.

Advantages of phytochemicals

- Cost-effectiveness
- Efficient in the control of pathogenic organisms
- Non-resistance forming renewable
- Non-residual effect on the aquatic animals
- Eco-friendly

Possible mode of application

Phytochemicals can be applied in different mode as therapeutic, growth promoter, feed additive etc. The various methods that can be followed are given below:

Oral route

Phytochemicals may be incorporated in the feed and fed to aquatic animals such as shrimp as reported by Choo, 1994. For example in carp culture systems, the required quantity of poultry feed supplements with various proportions of antibacterial activity which are commonly available to the fish farmers is added to the normal fish feed by mixing 4:1 mixture of de-oiled rice bran and oil cake into a dough (Rao et al., 1992).

Immersion method

This method can be used for external challenges such as external fungal problems. The phytochemical is added directly to the pond water or sprayed over the surface (Rao et al., 1992).

Dip treatment

In this method, the fish or shrimp are held in containers with a phytochemicals serving as a chemotherapeutant for short durations. This method is useful when a small portion of the stock is affected with non-systemic infections such as fouling, shell disease, necrosis of appendages, etc.

Bath treatment

This method is applicable only when a small portion of the stock is affected with disease. The fish can be given a bath treatment in

containers for about 30-60 min in a solution containing the phytochemicals.

One-time application

In one-time application, a low concentration of the phytochemical can be applied to the culture tanks or ponds for an indefinite period.

Injection

This method is practical to use when only a small number of large and valuable fish are to be treated.

Conclusion

The significance of phytochemicals to health and performance have been noted in various aquatic species. In general, phytochemicals have multiple effects in aquaculture. However, comprehensive knowledge regarding the uses, advantages and possible mode of administration principles is necessary for complete understanding of the aquaculture potential of these compounds.

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