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Medicinal Herbs, Strong Source of Antioxidant in Aquaculture: A Mini Review

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Abstract

As a result of the severe decline in major marine and freshwater fish stocks, aquaculture has been greatly developed throughout the world to provide global fish demands. Not surprisingly, the estimated risk of fish production failure was elevated due to the intensification of fish culture, amplification of environmental stressors, water quality deterioration, fish disease outbreak and finally high rates of fish mortality. Aqua culturists inevitably turned to antioxidant feed additives in order to overcome problems regarding the elevation of fish physiological fitness. Various natural and chemical additives have been successfully used in fish diet. However, the utilization rate of chemical supplements is limited because of their high price and also potential toxicity for fish in some cases. Recently, the use of plant products in aquaculture presents an increasing importance or significance. Plant products contain a broad range of active molecules such as flavonoids, terpenoids, ascorbic acid, tocopherols and phenolic compounds which can protect cells against xenobiotics and environmental stressors because of having strong antioxidant properties. This paper presents brief information about the potential advantages of applying herbal medicine as an antioxidant in aquaculture.

Keywords: Herbs; Fish health; Stress; Free radicals

Introduction

Oxidative stress can damage various important biological molecules. The most significant targets of cellular injury are proteins and DNA. Another target of ROS is the lipids of cell membranes [1]. Lipids attacked by free radicals subsequently convert to lipid peroxidation. This metabolite is toxic and is capable to damage most cells and tissues [2,3]. There are evidences for significant contribution of lipid per oxidation to the progress of atherosclerosis, stroke and myocardial infarction (Priscilla & Prince, 2009). They also could exert a cancer promotional effect when originated from dying cells [4].

Traditionally, herbal medicines or medicinal plants are thought to be a major source of treatment in human or animal disease [5]. Having a lower price and greater accuracy with the lower side effects compared to chemical additives, encouraged aquaculturist to increase the use of herbal products for promoting animal health and production [6,7]. Generally, some herbal plants have different functions due to the presence of numerous active compounds. Antioxidants are one of the main parts of the herbal structure with a high content of bioactive compounds which shown to have the ability to inhibit ROS generation and to scavenge free radicals [8]. Plants are a potential source for providing natural antioxidants. Carotenoids, flavonoids, tocopherols, cinnamic acid, folic acid, ascorbic acid, etc. are the most prominent antioxidants produced by plants [9]. In this paper, three main groups of antioxidants were briefly presented and some exemplifications of successful use of medicinal herbs in aquaculture are discussed.

Carotenoids

Carotenoids are organic pigments produced mostly by plants which can be found in flowers and leafy parts of Herbs, [10] varying in color from yellow, orange and red. Carotenoids are strong antioxidants with scavenging potential of free radicals. They provide protection against oxidative damage to cells. Herbs that are rich in carotenoids may have an immune stimulant function. They also possess slight anti-inflammatory action and can reduce the risk of heart disease and cancer [11]. Lycopene, is a red colored carotenoid found in many fruits, vegetables and herbs. Having a high number of conjugated dienes, recommends lycopene as the most potent antioxidant, with radical quenching ability twice more than β-carotene and 10 times higher than those recorded from α-tocopherol [12]. In agreements, lycopene plays a crucial role in preventing from serious diseases such as cancer, hypertension and cardiovascular disease and lead to improve immune function and normal metabolic reactions.

Carotenoids are known to have a various function in fish. Fish do not have the ability to synthesize carotenoids, they must obtain these compounds from their diets [13]. Carotenoids are usually transferred and deposited in different tissues including skin (as

xanthophyll esters in the chromatophore), muscle (astaxanthin especially in salmonids), the ovaries (carotenes during the reproduction in developing eggs) and liver [10]. Carotenoids transportation and deposition are carried in the circulatory system in association with lipoproteins. Fish eggs are one the main deposition site of the carotenoids. Vitellogenin, the precursor of the egg yolk lipovitelin, was suggested to function in carotenoids transportation, mainly Asthaxanthins, from the muscle to the ovary during spawning migration in salmonids. Carotenoids are believed that to have a fundamental role in successful egg fertilization, egg pigmentation and embryonic development [14].

Carotenoids are also the important source of vitamin A. Astaxanthin, canthaxanthin and zeaxaxanthin were found to be precursors of both vitamin A1 and A2 in some fishes. Liver and intestinal wall are active sites of carotenoids transformation into the vitamin A [13,15]. The rate of conversion is dependent on the vitamin A status and seems vary among different species [16].

Carotenoids are considered as non-enzymatic group of the cell's antioxidant system and provide two mechanisms to protect against oxidative damage: 1) quenching of singlet oxygen and 2) scavenging of radicals [17]. Therefore, beside of the different functions including skin and tissue pigmentation [16] and growth promotor [18], carotenoids have multifunction as antioxidant. A relationship between dietary carotenoids concentration and antioxidant status in liver and muscle was reported in Atlantic salmon [13] and rainbow trout [19].

Flavonoids

Flavonoids are a remarkably large group of natural phenolic compounds which are found universally in plants. To date, over 6000 chemical constituents have been isolated and identified as flavonoids [6]. Flavonoids are secondary metabolite of plants with polyphenolic structure. Synthesize of the flavonoids are take place by the polypropanoid pathway and phenylalanine is the startup molecule [20]. These bioactive compounds are confirmed to be plant, flower, leaf and fruits pigments. They can be derived from various vegetables, nuts, seeds, grains and herbs [4]. Flavonoids are naturally occurred in living cells as glycosides and may break down to their constituent, aglycone and sugar by enzymes treatment [21]. As a result of marked antioxidant characteristics of flavonoids, they have been considered as aprimary antioxidant which can act as free radical acceptor and chain breaker [22-24]. Moreover, they can render toxic metal ions catalytically inactive by chelation. This process has a critical role in detoxification of metals within the cells [21].

Generally, the antioxidant activities of flavonoids are mediated by the subsequent mechanisms:

a) Scavenging free radicals.

b) Suppressing ROS production via enzymes inhibition or Indentation is needed metals involved in ROS formation.

c) Protecting through antioxidant defenses [20].

Recently phenolics and flavonoids have been introduced as great antioxidants and several reports have emphasized on their higher effectiveness over well-known antioxidants, vitamin C, E and carotenoids [6,7,25]. Clove, sage, garlic, ginger, rosemary and thyme contain a considerable amount of flavonoids [5,21,26].

Tocopherols

Tocopherols are monophenolic antioxidants that can be widely found in nature. They include eight distinct compounds and related to two families, tocols and tocotrienols [21]. Tocopherols are widely produced and used as food antioxidant [21]. Depending on the number and location of methyl groups attached to the chromane rings, they have the prefix α, β, γ or δ [27,28]. α-tocopherol (well-known as vitamin E) is the most efficient member of this family. Vitamin E is one of the most effective free radical scavenging compounds that has a vital role in the normal structuring of cellular membrane [29]. In other words, the stability and function of cell membrane is completely dependent on the absorption capacity of the membrane when an extra amount of vitamin is available [27]. Vegetables and herbs, cereals and their products, seeds and nuts are the richest source of tocopherols [21]. The role of vitamin E in fish physiology and normal cellular function is well understood [3,30,31]. This vitamin is an essential nutrient required to maintain flesh quality, immunity, prevention from red blood haemolysis, the permeability of capillaries and heart muscle safety. As poly unsaturated fatty acids are the main and vital parts of the lipid structures in the fish body, the main function of vitamin E is to protect them against oxidation [32].

Antioxidant medicinal herb in aquaculture

Amongst the numerous herbal medicines, some of them have been successfully used in the fish diet. Medicinal herbs were used in aquaculture for different purposes. For example, herbs showed strong potential in a wide range of viral, bacterial or fungal disease [33-36]. Because of the fair price and strong effects of herbs, they have rapidly becoming a safe alternative for antibiotics and chemical drugs in aquaculture [8]. Elevation in growth performance and feed utilization of medicinal herbs are two important approaches in aquaculture. Active components within the herbs are believed to increase nutrient digestibility, absorption and assimilation capacity. Furthermore, these bioactive compounds can improve digestive enzymes secretion and maintain healthy intestinal microflora [25,37-40].

The use of medicinal herbs as an antioxidant source is a new approach in aquaculture. Intensive aqua farming systems have exposed the fish to several forms of stressors, as chemical, biological and physical disturbances, which can lead to severe alteration of the fish physiological condition. If these stressors surpass the fish biological threshold, the homeostasis will be disrupted and consequently stress outcomes will threat the animal's health [7]. Plants contain a wide variety of biochemical compounds with antioxidant properties. These can help organisms to cope with oxidative stress caused by environmental stressors, hence, keep the fish physiological fitness [41]. The amelioration of negative impacts

of environmental stressors by medicinal herb treatment in different fish species is represented in Table 1.

One of the most interesting characteristic of herbal antioxidants is related to their capacity to interact with other antioxidants. In this regards, antioxidants act synergistically, offering more protection than single administration. Antioxidants derived from plants, as polyphenols and flavonoids, may increase the effectiveness of vitamins [42] and may have compensatory effects when the vitamin levels are low [43]. In agreement, Antache et al. [44] stated that administration of thyme in combination with vitamin E had a synergistic effect on growth performance and reducing lipid peroxidation in Nile tilapia Mekkawy et al. [45] were also emphasized on the probable additive or synergistic effects of tomato paste carotenoids and vitamin E protecting from harmful effects of cadmium in Nile tilapia (Table 1)[46-53].

Table 1: Some medicinal herbs with antioxidant properties and their successful application for control of stress in different fish species

Medicinal Herb	Main Antioxidant Compounds	Fish Species	Effects	References
Thyme (*Zataria multi flora Boiss*)	Thymol, Carvacrol, γ-Terpinene, α-terpinene, p-cymene	*Cyprinus carpio*	Improvement in growth, health and hepatic function of the fish exposed to waterborne cadmium	[26]
Ginseng (*Araliaceae*)	Panaxadiol, Ginsenosides	*Oreochromis niloticus*	Enhanced growth performance, diet utilization efficiency, and hematological indices	[38]
Marsh mallow (*Althaea officinalis*)	Anthocyanins, Carvacrol, Dodecanoic acid, Thymol	*Cyprinus carpio*	Decreasing plasma cholesterol levels, healthy hepatic function	[46]
Sage (*Salvia officinalis*)	Rosmarinic acid, Salvianolic acid, Sagecoumarin, Sagerinic acid, Catechol	*Oncorhynchus mykiss*	Significant increase in antioxidant enzyme activities and significant reduction in TBARS levels	[47]
Wood betony (*Stachys lavandulifolia*)	Alkaloid,Saponins, Nicotinic acid	*Cyprinus carpio*	Improve liver function and response to acute stress	[48]
Rosemary (*Rosmarinus officinalis*)	Phenolic diterpenes, Primarily Carnosic acid, Carnosol, Rosmanol, and Epi- and Isorosmanol	*Oreochromis niloticus*	Oxidative stress was reduced in recirculating aquaculture system	[49]
Fenugreek (*Trigonella foenum graecum*)	Apigenin, Kaempferol and Quercetin, Diosgenin and Yamogenin	*Dicentrarchus labrax*	Improvement in the protein and energy retentions, hepatorenoprotective effects	[50]
Garlic (*Allium sativum*)	Allyl cysteine, Alliin, Allicin and Allyl disulfide	*Oreochromis niloticus*	Beneficial effect in preventing heavy metal (copper and zinc) induced alteration of lipid profile	[51]
Rhubarb (*Rheum officinale*)	Anthraquinone	*Cyprinus carpio*	Prevent the pathogenic infection, mitigate the negative effects of crowding stress, and promote the growth of the fish	[52]
Coffee bean (*Coffea arabica*)	Caffeine, Cafestol, Kahweol, and Chlorogenic acids	*Cyprinus carpio*	Improve fish immunity and reduce the impact of water-born Zn toxicity and bioaccumulation in fish body	[53]

Conclusion and Perspectives

Medicinal herbs represent a potential resource in aquaculture with a large application field. They can be used as appetite stimulator, antimicrobial and antiviral effectors, immune stimulant and growth promoter. Due to their bioactive ingredients, e.g. polyphenols, flavonoids, tocopherols and essential oils, medicinal herbs present antioxidant properties and can be used as anti-stress remedy in aquaculture. This approach can reduce the costs and side effects of synthetic or chemical products. Medicinal herbs are also eco-friendly compounds and hence will not affect the environment. Despite to the presence of numerous antioxidant compounds in the most medicinal plants, but a few of them have been considered as a feed additive in fish diet. It seems that our knowledge about their application to aquatic animal health and production is still limited and further studies on this subject are needed [54-56].

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