Benefits of Plant Pigment, Quercetin, for Fish and Prawn

Yos Adi Prakoso
Department of Pharmacology, Faculty of Veterinary Medicine, Universitas Wijaya Kusuma Surabaya, Surabaya 60225, Indonesia, yos.vet.docter@gmail.com

Jasir Hakim Hidayah
Department of Pharmacology, Faculty of Veterinary Medicine, Universitas Wijaya Kusuma Surabaya, Surabaya 60225, Indonesia

Michael Richard Sanjaya
Department of Pharmacology, Faculty of Veterinary Medicine, Universitas Wijaya Kusuma Surabaya, Surabaya 60225, Indonesia

Agga Dhigayuka Pratama
Veterinary Therapeutics Station, Faculty of Veterinary Medicine, Universitas Wijaya Kusuma Surabaya, Surabaya 60225, Indonesia

Annisha Permata Nurul Azhar
Veterinary Therapeutics Station, Faculty of Veterinary Medicine, Universitas Wijaya Kusuma Surabaya, Surabaya 60225, Indonesia

Follow this and additional works at: https://scholarhub.ui.ac.id/science

Part of the Other Veterinary Medicine Commons

Recommended Citation
Prakoso, Yos Adi; Hidayah, Jasir Hakim; Sanjaya, Michael Richard; Pratama, Agga Dhigayuka; Azhar, Annisha Permata Nurul; Kuswanto, Arya Surya; April, Berlian Ronaldi; Utami, Intan Karisma; Putra, Mahera Sandi Sasmita; Wukak, Maria Paulina; and Satria, Naufal Farros (2024) "Benefits of Plant Pigment, Quercetin, for Fish and Prawn," Makara Journal of Science: Vol. 28: Iss. 2, Article 5.
DOI: 10.7454/mss.v28i2.1487
Available at: https://scholarhub.ui.ac.id/science/vol28/iss2/5

This Article is brought to you for free and open access by the Universitas Indonesia at UI Scholars Hub. It has been accepted for inclusion in Makara Journal of Science by an authorized editor of UI Scholars Hub.
Benefits of Plant Pigment, Quercetin, for Fish and Prawn

Authors
Yos Adi Prakoso, Jasir Hakim Hidayah, Michael Richard Sanjaya, Agga Dhiayuka Pratama, Annisha Permata Nurul Azhar, Arya Surya Kuswanto, Berlian Ronaldi April, Intan Karisma Utami, Mahera Sandi Sasmita Putra, Maria Paulina Wukak, and Naufal Farros Satria

This article is available in Makara Journal of Science: https://scholarhub.ui.ac.id/science/vol28/iss2/5
Abstract

Quercetin is an important phytochemical that belongs to the flavonoid group of plant pigments. It has potential benefits as an antioxidant, antiviral, and anti-inflammatory agent. However, the utilization of quercetin in aquaculture is not optimal. Hence, this study conducted a literature review to analyze the potential benefits of quercetin in aquaculture, especially for fish and prawn. Results showed that quercetin can be isolated from herbs using several methods, including sonication, maceration, and fractionation. Its amount in plants can be potentially determined using high-performance liquid chromatography and thin-layer chromatography. Some of the plants containing high quercetin levels include shallot, garlic, apple skin, guava leaves, green tea, chia seeds, and desert rose flower. In aquaculture, quercetin can be applied to increase the ideal body weight, feed conversion ratio, and condition factor of aquatic cultured species and serves as an antioxidant, antistress, strengthening probiotic and an antiinfective agent. Latest research showed that quercetin benefits the immunity of goldfish against furunculosis. Furthermore, quercetin shows potential in prawn industry as an antioxidant protection that improves the meat quality. The minimum utilization can be attributed to the lack of a systematic review regarding its potency either on fish or prawn. Hence, this study provides the essential review of quercetin in aquaculture.

Keywords: aquaculture, fish, prawn, quercetin

Introduction

Aquaculture is the cultivation of aquatic animals. Intervention during rearing is needed to increase production regarding stocking density, feeding, and protection from predators [1]. Aquaculture has become the world’s most essential protein source [2]. However, some of the obstacles in the development of this practice, including climate changes, stress, and disease, lead to economic losses. These problems impact the aquaculture production. One of the important ways to support aquaculture production and prevent economic loss is to utilize antioxidants derived from herbs, such as quercetin.

Quercetin is an essential plant pigment belonging the flavonoid group and is found in various fruits, vegetables, flowers, leaves, and seeds [3]. Some of the plants containing high quercetin levels include shallot, garlic, apple skin, guava leave, green tea, chia seed, and desert rose flower. Quercetin is classified as a water-soluble pigment and cannot be naturally produced by animals. It is also a phytoestrogen consisting of three rings and 5-hydroxyl groups with various health benefits [4]. Quercetin has pharmacological activities, such as antioxidant, anticancer, antiviral, antimicrobial, neuroprotective, cardiovascular, and antiobesity [5]. It can increase the ideal body weight (IBW), feed conversion ratio (FCR), and condition factor (CF) in fish [6] and improve the meat quality of prawn [7].

Unfortunately, the various potential benefits of quercetin are still not fully utilized due to the lack of information about this compound, especially its systematic review. Therefore, this review aims to provide information regarding the potential of quercetin for aquaculture.
Quercetin and Its Benefits

Quercetin is a flavonoid found in various herbs and has the formula \(2-(3,4\text{-dihydroxyphenyl})-3,5,7\text{-trihydroxy chromen-4-one}\) (Figure 1). It has catechol groups in ring B and three \(-\text{OH}\) groups in rings A and C, which capture free radicals. The chemical stability of this compound can be affected by pH and metal ions [8]. Quercetin can be isolated from plants using several methods as listed in Table 1.

The name quercetin has been used since 1857 and derived from \textit{quarcetum}, which means oak. This flavonoid has various biological properties, including antioxidant, anti-inflammatory, antibacterial, antiviral, radical scavenging, gastroprotective, and immune modulating [14]. Quercetin can be found in plants and fruits. Shallots (\textit{Allium cepa}) contain quercetin that could be used as an anti-inflammatory agent [4]. Moreover, the quercetin derived from garlic (\textit{Allium sativum}) has an antihypertensive function [15]. Another study reported that the skin part of apples (\textit{Malus domestica}) contains quercetin that is commonly used as antioxidant [16]. In addition, quercetin can be found in the leaves and seeds. Some of the fruit leaves that contain quercetin are guava (\textit{Psidium guajava}) and green tea (\textit{Camellia sinensis}). Meanwhile, chia (\textit{Salvia hispanica}) has quercetin in its seeds. The quercetin from guava leaves and green tea functions as antioxidant [17, 18], and that from chia seeds shows potential as anticancer [19]. Several of the medical benefits of quercetin derived from herbs are listed in Table 2.

![Figure 1. Chemical Structure of Quercetin [8]](image)

Table 1. Procedures to Isolate and Determine Quercetin Level from Herbs

<table>
<thead>
<tr>
<th>Source</th>
<th>Isolation and Determination Methods</th>
<th>Quercetin Content</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guava leaves (\textit{Psidium guajava})</td>
<td>Sonication methanol–water (85:15)</td>
<td>2.15%</td>
<td>[9]</td>
</tr>
<tr>
<td>\textit{Aesculus indica}</td>
<td>Fractionation of 300 g crude extract + 900 ml methanol</td>
<td>6.74 mg/100 g</td>
<td>[10]</td>
</tr>
<tr>
<td></td>
<td>Maceration powder sample + 90% methanol</td>
<td>1.22 mg/100 g</td>
<td></td>
</tr>
<tr>
<td>\textit{Lagerstroemia speciosa}</td>
<td>High performance liquid chromatography (HPLC)</td>
<td>91.66%</td>
<td>[11]</td>
</tr>
<tr>
<td>\textit{Okra Fruit} (\textit{Abelmoschus esculentus} L.)</td>
<td>Thin layer chromatography (TLC Densitometry)</td>
<td>8.358 mg/mL</td>
<td>[12]</td>
</tr>
<tr>
<td>\textit{Red Onion} (\textit{Allium cepa} L.) Scales</td>
<td>HPLC</td>
<td>4.6 mg/kg</td>
<td>[13]</td>
</tr>
</tbody>
</table>
Table 2. Quercetin Derived from Herbs and its Potential Benefits

<table>
<thead>
<tr>
<th>Source</th>
<th>Role</th>
<th>Quercetin Levels</th>
<th>Dosage</th>
<th>Activities Undertaken</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shallot (Allium cepa)</td>
<td>Anti-inflammatory</td>
<td>22 mg/100 g</td>
<td>2 g/kg BW</td>
<td>The anti-inflammatory effect of quercetin produces an inhibitory action on cyclooxygenase and lipoxygenase enzymes and inhibits inflammatory mediators such as prostaglandins and leukotrienes</td>
<td>[4]</td>
</tr>
<tr>
<td>Garlic (Allium sativum)</td>
<td>Antihypertensive</td>
<td>16.35 mg/100 g</td>
<td>100mg/mL</td>
<td>Stimulates the constricting and relaxing factors of the endothelium which causes a decrease in blood pressure</td>
<td>[15]</td>
</tr>
<tr>
<td>Apple skin (Malus domestica)</td>
<td>Antioxidants</td>
<td>21–72 mg/100 g</td>
<td>20–40 mg/kg</td>
<td>Suppresses COX gene expression, stimulates glutathione-S-transferase (GST)</td>
<td>[16]</td>
</tr>
<tr>
<td>Guava leaves (Psidium guajava)</td>
<td>Antioxidant</td>
<td>0.01–5.11 mg/100 g</td>
<td>10 g, soaked in 100 mL 70% ethanol/water</td>
<td>Suppresses COX gene expression, stimulates glutathione-S-transferase (GST)</td>
<td>[17]</td>
</tr>
<tr>
<td>Green tea (Camellia sinensis)</td>
<td>Antioxidant</td>
<td>1.50 mg/100 g</td>
<td>0.05–0.80 g/kg in 300 L of water</td>
<td>Suppresses COX gene expression, stimulates glutathione-S-transferase (GST)</td>
<td>[18]</td>
</tr>
<tr>
<td>Chia seeds (Salvia hispanica)</td>
<td>Anticancer</td>
<td>0.17µg/100 g</td>
<td>3.79 g in 1:1 feed</td>
<td>Decreased triglycerides and increased HDL cholesterol</td>
<td>[19]</td>
</tr>
</tbody>
</table>

**Benefits of Quercetin in Aquaculture**

**Antioxidant and antiviral.** As an antioxidant, quercetin reduces several cellular damage and oxidation processes. It can bind to free radicals and transform metal ions [4]. The decrease in oxidation within a fish body can protect its erythrocytes from further damage [20]. Oxidizing the inhibitory protein Kelch-like ECH-associated protein 1 within the nucleus increases the level of nuclear factor-erythroid-2 related factor 2 (Nrf2) [21]. Nrf2 interferes with the nucleus to activate various antioxidant genes such as superoxide dismutase, glutathione peroxidase, and heme oxygenase-1 [22]. Quercetin from herbs could also be used to inhibit the hemagglutinin of influenza virus by disrupting its transcription at 24 hours post infection [23]. This ability was proved by an in vitro study using Madin–Darby canine kidney infected with influenza virus. Moreover, quercetin can reduce the pathogenicity of hepatitis virus C (HCV) from JFH1 strain [23]. In aquaculture, quercetin effectively increases the survival rate of trout and salmon infected by infectious pancreatic necrosis virus (IPNV) by inhibiting the pathogenicity of this virus. Minimal doses of 10, 20, and 50 mmol/L quercetin have been used to treat IPNV infection [24].

**Anti-inflammatory.** As an anti-inflammatory agent, quercetin blocks cyclooxygenase and lipoxygenase that impair the prostaglandin and leukotrienes [25, 26]. In addition, it inhibits the mRNA expression levels of TNF-α and interleukin-1α [27]. The decrease in inflammation potentially increases the survival rate of the fish and maintain its blood homeostasis. It also facilitates the immune-expression of T cells to induce healing after infection. Meanwhile, T cells are part of the main cellular response in fish.

**Current Application of Quercetin for Fish**

Quercetin significantly improved lipid metabolism and reduces hepatocyte apoptosis in blunt snout bream (Megalobrama amblycephala) supplemented with a high-fat diet [28]. Moreover, 40 mg/kg quercetin derived from Allium mongolicum increased the lysozyme activities in olive flounder (Paralichthys olivaceus) [29] and Channa argus [30]. These abilities allow quercetin
to increase body metabolism function and protect the liver from destruction. Another study using a mixture of quercetin and feed with ratios of 400/1600, 600/1600, and 800/1600 reported that 400 mg of quercetin increased the IBW of male tilapia (Oreochromis niloticus) [6]. In particular, the lowest concentration induced the maximum progress during 7 days of treatment. This study also demonstrated that the combination of quercetin and feed increased the enzyme activity and reduce lipid peroxidation on the fish muscles, potentially influencing the fish meat quality and body weight.

Moreover, quercetin can be applied in fish for immersion therapy by dissolving it in water. Quercetin dissolved in water at 1 µg/L concentration can significantly reduce the stress in male zebrafish (Danio rerio) [31]. It is also applied in aquaculture to decrease stress after antibiotic administration during 14 days of treatment [32]. The ability of quercetin to decrease stress among fish is supported by its chelating activities on neuronal cells. The secondary metabolic product of quercetin supports neuronal integrity and prevents serious oxidative stress in the brain [33].

Nowadays, probiotics are used to prevent diseases in aquaculture. These microorganisms are essential to protect the digestive system and skin of fish from pathogenic bacteria. As an antiviral, anti-inflammatory, and antioxidant agent, quercetin shows potential to aid probiotics by increasing the colonization of Bacillus spp. and Lactobacillus spp. on the intestine of fish. This ability has already been proven [34]. Quercetin can also support the probiotic function in Odontobutis potamophila and O. obscura by enhancing the good bacteria in the body that increase feed absorption rate.

Quercetin has been isolated from desert rose (Adenium obesum (Forsk.) Roem. & Schult) and elucidated as an antibacterial agent against Aeromonas salmonicida infection in oranda goldfish (Carassius auratus auratus) [35]. The potency of quercetin is not only as an antibacterial agent but also for promoting the immune-expression of circulatory CD4+/CD8+ lymphocytes, improving hepatopancreatic and hematopoietic systems, and reducing tissue inflammation in furunculosis [35].

Current Application of Quercetin for Prawn

As an important aquaculture product, prawn has received major concern in the aquaculture industry and its production is essential for export. One of the procedures to support prawn production is to use quercetin. The quercetin derived from Phyllanthus urinaria extract has been used in prawn, especially vannamei shrimp (Litopenaeus vannamei), to increase their resistance and viability against the environmental conditions in ponds [36]. A previous study reported that 1% quercetin inhibited the growth of Vibrio parahaemolyticus on the body surface of shellfish [37]. Quercetin was mixed with water in a biofloc technology system (BFT) to maintain the water quality for L. vannamei [38]. A significant effect was observed after supplementation using 0.79±0.35 g quercetin for 30 days. This study also showed that quercetin has essential benefits of decreasing lipid peroxidation and increasing muscle mass relative to those of the fish without quercetin supplement. Moreover, the application of quercetin within the BFT system is not disturbing to the water quality parameters. These findings prove that quercetin is safe to be used in aquaculture, both for the organism and the environment.

Perspective

Quercetin has benefits in aquaculture that have been proven by several studies. It can be formulated as a feed supplement or a mixture for probiotics and water treatment. The utilization of quercetin in animal models infected by an infectious agent is warranted in the future. Quercetin can be formulated using simple and advance methods, depending on the technology-based target. Nevertheless, the standardization of quercetin and its biosafety and security must be explored in the future.

Quercetin may have several benefits in aquaculture production. As mentioned above, it decreases oxidative stress that influences the fish ability to tolerate diseases and climate changes. Healthy fish living in aquaculture generate high-quality fish and prawn products that maintain the taste and guarantee food safety [39]. The application of quercetin in fish feed is also essential to prevent the decrease in fish food quality during production. This finding is supported by a previous study, which found that the utilization of quercetin polymer-encapsulated food during the grower fish stage optimally prevented bacterial infection [40]. Moreover, the increase in fish and prawn survival rate during pre- and postinfective stages may increase the production, which is essential in improving farmer’s income and preventing severe economic losses.

Conclusion

As an antioxidant, antiviral, and anti-inflammatory agent, quercetin has potential benefits in aquaculture and may be developed as feed supplement and water treatment. Furthermore, it has been used to increase IBW, FCR, and CF, aid probiotics in fish production, and fight against furunculosis. The aquaculture industry can use quercetin as an alternative to improve the processes, mitigate diseases in an environment-friendly way, and prevent economic losses.

Acknowledgements

This study was partially supported by Dept. Pharmacology, FVM, UWKS, with grant number: 12/XII/2022. All the
laboratory assistants from Dept. Pharmacology were acknowledged for their assistance in this study.

References


