

# Application of Black Cumin Oil (*Nigella sativa*) in Aquaculture: A Review of the Potential for Growth and Immunity Enhancement

## *Aplikasi Minyak Jintan Hitam (Nigella sativa) dalam Akuakultur: Tinjauan Potensi untuk Peningkatan Pertumbuhan dan Imunitas*

Bagus Susilo<sup>1\*</sup>, Fitrie Meyllianawaty Pratiwy<sup>1</sup>, Iskandar<sup>1</sup>, Rafidah Othman<sup>1</sup>,  
Roffi Grandiosa Herman<sup>1</sup>

<sup>1</sup>Department of Fisheries, Faculty of Fisheries and Marine Science, Universitas Padjajaran,  
Sumedang 45363 Indonesia

\*email: [bagus21001@mail.unpad.ac.id](mailto:bagus21001@mail.unpad.ac.id)

---

### Abstract

Received  
20 January 2026

Accepted  
25 February 2026

Black cumin oil (*Nigella sativa*) is a natural ingredient that contains various bioactive compounds, including thymoquinone, flavonoids, and essential fatty acids, with antioxidant, anti-inflammatory, and immunostimulating effects. In the field of aquaculture, the use of black cumin oil as a feed supplement is being developed due to its potential in improve the growth performance and immune system of farmed fish. This article aims to systematically review research on the application of black cumin oil in aquaculture, focusing on improving fish growth rate and immune response. Based on a literature review, it was found that *N. sativa* supplementation in oil form in various fish species, such as *Oncorhynchus mykiss*, *Clarias gariepinus*, *Oreochromis niloticus*, and *Anabas testudineus*, was able to improve growth, feed conversion ratio, as well as immunological parameters such as phagocytic activity, immunoglobulin levels, and resistance to infection.

**Keywords:** Black cumin oil, Aquaculture, Fish growth, Immune response

---

### Abstrak

Minyak jintan hitam (*Nigella sativa*) merupakan bahan alami yang mengandung berbagai senyawa bioaktif seperti thymoquinone, flavonoid, dan asam lemak esensial yang diketahui memiliki efek antioksidan, anti-inflamasi, dan imunostimulan. Dalam bidang akuakultur, pemanfaatan minyak jintan hitam sebagai suplemen pakan sudah mulai dikembangkan karena potensinya dalam meningkatkan performa pertumbuhan serta sistem kekebalan tubuh ikan budidaya. Artikel ini bertujuan untuk mengulas secara sistematis hasil-hasil penelitian yang berkaitan dengan aplikasi minyak jintan hitam dalam akuakultur, dengan fokus pada peningkatan laju pertumbuhan dan respon imun ikan. Berdasarkan tinjauan literatur, ditemukan bahwa suplementasi *N. sativa* dalam bentuk minyak pada berbagai spesies ikan seperti *Oncorhynchus mykiss*, *Clarias gariepinus*, *Oreochromis niloticus*, dan *anabas testudineus* mampu meningkatkan pertumbuhan, rasio konversi pakan, serta parameter imunologi seperti aktivitas fagositik, kadar imunoglobulin, dan resistensi terhadap infeksi.

**Kata kunci:** Minyak jintan hitam, Akuakultur, Pertumbuhan ikan, Respon imun

---

## 1. Introduction

Aquaculture is a vital sector of the global food system, currently accounting for approximately 15% of global animal protein supply. Projections indicate a 62% increase in production by 2030 to meet growing consumption demands (Reverter et al., 2020). These conditions encourage people's interest in developing fish farming activities, along with the increasing market demand. However, one of the main challenges in this endeavor is the high risk of disease outbreaks, which can significantly affect growth and decline in production levels (Affandi & Setyono, 2023). To overcome these problems, the use of natural ingredients as alternative feed additives has begun to receive attention, especially those with the potential to support growth and strengthen fish's immune systems. The integration of herbal essential oils in aquatic animal feed formulations is recommended due to their potential to stimulate growth, strengthen the immune system, and reduce free radical activity (Magouz et al., 2021).

One of the promising natural agents is black cumin (*Nigella sativa*), which is native to the Eastern Mediterranean region, North Africa, Southeast Asia, India, and has long been cultivated in the Ethiopian region, where it is traditionally known and utilized for its medicinal properties (Alberts et al., 2024). Black cumin is widely known to contain flavonoids, alkaloids, saponins, tannins, and terpenoids (including thymoquinone and thymol). These compounds have antibacterial activity (Hidayat et al., 2022). In addition, black cumin contains unsaturated fatty acids (UFA; 85.16%) in the form of linoleic acid (57.71%) and oleic acid (24.46%) (Albakry et al., 2022).

Several studies have shown that black cumin oil (*Nigella sativa*) positively affects fish growth performance, immune response, and resistance to disease. Research conducted on rainbow trout (*Oncorhynchus mykiss*) indicated that the addition of black cumin oil to the feed significantly improved growth performance parameters, including specific growth rate (SGR), feed conversion rates (FCR), and protein efficiency ratio (PER), where a dose of 1.00% proved to be the most effective (Öz et al., 2018). Similarly, a study on Nile tilapia (*Oreochromis niloticus*) fed with 1% black cumin (*Nigella sativa*) oil improved hematological immune responses, blood biochemistry, and histopathological parameters (Öz et al., 2024). This article aims to comprehensively review the potential use of black cumin oil (*Nigella sativa*) in aquaculture, with a focus on improving growth performance and immunity of farmed fish.

## 2. Material and Method

The method used is descriptive, namely a literature review of various libraries on ScienceDirect and Google Scholar, using the keywords aquaculture, black cumin oil, *Nigella sativa*, fish growth, and immune response. This systematic and comprehensive search strategy allows the development of a theoretical framework that is in line with the main themes identified in the existing literature.

## 3. Result and Discussion

### 3.1. Bioactive Components of Black Cumin Oil (*Nigella sativa*)

Black cumin (*Nigella sativa*) essential oil is a rich source of bioactive compounds, such as p-cymene, thymoquinone,  $\alpha$ -thujene, longifolene,  $\beta$ -pinene,  $\alpha$ -pinene, and carvacrol. Such high phytochemical content is in significant importance for nutrition and health applications. The oil is also known to possess a wide array of biological activities, including antifungal, antibacterial, and antioxidant properties (Alu'datt et al., 2024). The main components in *Nigella sativa* essential oil are thymoquinone, o-cymene, and  $\beta$ -thujene, which comprise 21.01%, 18.23%, and 17.22%, respectively (Albakry et al., 2022).

Black cumin oil contains essential fatty acids, notably linoleic and oleic acids. It is also rich in vitamins A, B1, B6, C, biotin, folic acid, and niacin, as well as key minerals such as zinc, magnesium, calcium, selenium, and iron. In addition to its rich nutritional profile, black cumin oil exhibits notable pharmacological properties. Its bioactive compounds are widely recognized for their antibacterial, antifungal, antiviral, antiprotozoal, antihistaminic, antioxidant, anti-inflammatory, and immunostimulatory effects (Öz et al., 2024). The following in Table 1 are some studies on the administration of black cumin oil (*Nigella sativa*) in the field of aquaculture.

### 3.2. Bioactive Components of Black Cumin Oil (*Nigella sativa*)

In aquaculture, growth performance is generally evaluated by measuring body weight gain, feed conversion ratio (FCR), and specific growth rate (SGR). These three parameters serve as key indicators to assess the efficiency and effectiveness of feed formulations. Several studies have shown that black cumin oil supplementation in fish feed significantly improves these growth parameters. Studies conducted by Öz et al. (2024) on Tilapia (*O. niloticus*) showed that feeding with an additional 1.00% black cumin oil resulted in a significant increase in fish weight gain of 18.25g, FCR of 1.02, and SGR of 1.29%/day compared to the control group. The nutritional content and pharmacological properties possessed by black cumin oil play a role in stimulating fish growth, increasing appetite, and strengthening disease resistance. In addition, it is thought to reduce stress induced by cipermethrin,

increase feed consumption by stimulating digestive enzyme activity, and thus support improved growth performance.

Table 1. Administration of Black Cumin Oil (*Nigella sativa*) in Aquaculture

No	Fish Species	dose	Effects Found	Reference
1	Nile tilapia ( <i>O. niloticus</i> )	1 %	significantly improved fish growth, hemato-biochemical parameters, and histopathologic tissues.	(Öz et al., 2024)
2	Rainbow trout ( <i>O. mykiss</i> )		increases growth performance in fish and decreases production costs.	(Öz et al., 2018)
3	Nile tilapia ( <i>O. niloticus</i> )	1 %	Black cumin oil has demonstrated superior histopathological improvements, enhanced immune responses, and contributed to overall health and increased resistance to infections.	(Ibrahim et al., 2025)
4	Climbing Perch ( <i>A. testudineus</i> )	30%	increased immune response, decreased mortality, and increased survival rate after challenge with <i>Aeromonas hydrophila</i> .	(Khatun et al., 2015)
5	Nile tilapia ( <i>O. niloticus</i> )	2 %	Significantly enhanced Nile tilapia survival. Overall, the growth metrics, innate immunity, and survival recorded in black cumin oil-fed fish appeared to be the best among all fish groups, including the control.	(Dey et al., 2020)
6	Rainbow trout ( <i>O. mykiss</i> )	1% and 10%	The results of this study revealed that <i>Nigella sativa</i> oil has a positive effect on the immune response of rainbow trout, characterized by an increase in serum bactericidal activity, lysozyme activity, and myeloperoxidase levels.	(Ispir et al., 2024)
7	Rainbow trout ( <i>O. mykiss</i> )	1% quercetin and 3% black cumin oil	showed a highly significant difference ( $p < 0.05$ ) in lysozyme, total protein, antiprotease, and bactericidal activity	(Awad et al., 2013)

Similar research by Öz et al. (2018) on Rainbow trout found that feed supplementation with black cumin oil at 1.00% improved growth performance. Rainbow trout fed with feed supplemented with black cumin oil showed a weight gain of 260.14g, SGR1.02%/day, and FCR 0.77 compared to the control group. The increase in fish growth can be attributed to black cumin oil in the feed as a source of essential fatty acids needed by the fish. The absorbed fat is used as an alternative energy source to support metabolic processes, allowing for a more efficient allocation of feed protein to growth rather than simply as an energy source. Black cumin oil is known to be rich in essential fatty acids, with linoleic, oleic, and palmitic acids as the dominant components in its lipid profile (Rahim et al., 2022).

### 3.3. Effects of Black Cumin Oil on Immunity

According to the findings of Ibrahim et al. (2025), feed supplementation with black cumin oil in tilapia infected with *Aeromonas veronii* increased red blood cell parameters, hemoglobin, and leukocyte counts, including lymphocytes, monocytes, and neutrophils. The increase in leukocyte cell count reflects the activation of the fish's immune response to pathogen attack. Variations in leukocyte response to infection are thought to be part of the organism's adaptation mechanism in the face of disease stress. The increase in the number of immune cells indicates that black cumin oil has the potential to strengthen the immune response of fish in the face of pathogen infection. Similar research by Ispir et al. (2024) intraperitoneal injection of *Nigella sativa* oil (NSO) in rainbow trout at concentrations of 1% and 10% showed significant improvements in most immunological parameters, with the exception of total protein and immunoglobulin levels. These findings indicate that *Nigella sativa* can effectively stimulate innate immune responses. Thus, NSO has great potential to be utilized as a natural immunostimulant in an effort to improve fish health and disease resistance. The main ingredients in black cumin essential oil, such as thymoquinone, thymohydroquinone, dithymoquinone, and thymol, as well as tannin compounds, have been shown to exhibit effective antibacterial and antifungal activities (Jamil et al., 2014).

### 3.4. Effectiveness of black cumin oil in warding off disease attacks

Research conducted by Mohammed & Arias (2016) showed that administering 5% black cumin oil to fish feed can inhibit the growth of all tested *F. columnare* strains and produce a zone of inhibition much greater than that produced by oxytetracycline. The study also showed that catfish (*Ictalurus punctatus*) and zebrafish (*Danio rerio*) fed modified diets containing 5% black cumin oil had significantly lower mortality rates than those fed control diets. This finding indicates that black cumin oil has significant antimicrobial potential in inhibiting or eliminating these pathogenic bacteria. This result has important implications for the aquaculture sector, as it offers a safer, natural alternative to synthetic antibiotics. A similar study by Dey et al. (2020) showed that adding 2% black cumin oil (BCSO) to feed enhanced innate immunity and reduced mortality in Nile tilapia exposed to *Pseudomonas fluorescens*, suggesting potential applications for immune enhancement in aquaculture.

## 4. Conclusions

Black cumin oil (*Nigella sativa*) is one natural ingredient with potential for application in aquaculture systems, especially in efforts to increase growth and modulate fish immune systems. Several studies have shown that *N. sativa* supplementation in feed can increase specific growth rate (SGR) and feed conversion ratio (FCR), and strengthen immune responses, both non-specific (e.g., phagocytic activity and leukocyte count) and specific (e.g., immunoglobulin levels). This effectiveness is generally attributed to the presence of bioactive compounds, such as thymoquinone, flavonoids, and essential fatty acids that have antioxidant, anti-inflammatory, and immunostimulatory properties.

## 5. References

- Affandi, R.I., & Setyono, B.D.H. (2023). Potensi tanaman sambiloto (*Andrographis paniculata*) sebagai imunostimulan pada ikan. *Jurnal Vokasi Ilmu-Ilmu Perikanan*, 4(1): 131.
- Albakry, Z., Karrar, E., Mohamed Ahmed, I.A., Oz, E., Proestos, C., El Sheikha, A.F., Oz, F., Wu, G., & Wang, X. (2022). Nutritional composition and volatile compounds of black cumin (*Nigella sativa* L.) seed, fatty acid composition and tocopherols, polyphenols, and antioxidant activity of its essential oil. *Horticulturae*, 8(7): 1–10.
- Alberts, A., Moldoveanu, E.T., Niculescu, A.G., & Grumezescu, A.M. (2024). *Nigella sativa*: A comprehensive review of its therapeutic potential, pharmacological properties, and clinical applications. *International Journal of Molecular Sciences*, 25(24).
- Alu'datt, M.H., Rababah, T., Al-u'datt, D.G.F., Gammoh, S., Alkandari, S., Allafi, A., Alrosan, M., Kubow, S., & Al-Rashdan, H.K. (2024). Designing novel industrial and functional foods using the bioactive compounds from *Nigella sativa* L. (black cumin): Biochemical and biological prospects toward health implications. *Journal of Food Science*, 89(4): 1865–1893.
- Awad, E., Austin, D., & Lyndon, A.R. (2013). Effect of black cumin seed oil (*Nigella sativa*) and nettle extract (*quercetin*) on enhancement of immunity in rainbow trout, *Oncorhynchus mykiss* (Walbaum). *Aquaculture*, 388–391(1): 193–197.
- Dey, B.K., Hossain, M.M.M., & Alam, M.E. (2020). Effect of black cumin seed oil on growth, innate immunity, and resistance against *Pseudomonas fluorescens* infection in Nile tilapia *Oreochromis niloticus*. *Aquaculture International*, 28(4): 1485–1499.
- Hidayat, L.N.R., Riyadi, S.A., Gustiani, S., & Dwicahya, A. (2022). Application of black cumin extract (*Nigella sativa* L.) as an antibacterial agent on cotton fabrics with various methods. *Arena Tekstil*, 37(1): 9–18.
- Ibrahim, S.E., Abdelhamid, F.M., ElGheit, E.N.A., El-kady, M.A.H., Elshopakey, G.E., & Risha, E.F. (2025). Dietary intervention of ginger and black seed oils boosted hematology, biochemical profile, and antioxidant-immune responses in *Oreochromis niloticus* challenged with *Aeromonas veronii*. *Aquaculture*, 603, 742398.
- Ispir, U., Ozcan, M., & Kirici, M. (2024). Effects of *Nigella sativa* oil on immune mechanisms in rainbow trout, *Oncorhynchus mykiss*. *International Journal of Pure and Applied Sciences*, 10(2): 446–458.
- Jamil, A.S., Adi, B., Prasaja, B., Ariani, A., & Hardi, Z. (2014). Aktivitas antimikroba ekstrak biji *Nigella sativa* terhadap viabilitas bakteri probiotik secara in vitro dan in vivo. *Jurnal Farmasi Indonesia*, 1: 1–17.
- Khatun, A., Hossain, M., Rahman, M., Alam, M., Yasmin, F., Islam, M., & Islam, M. (2015). Effect of black cumin seed oil (*Nigella sativa*) on enhancement of immunity in the climbing perch, *Anabas testudineus*. *British Microbiology Research Journal*, 6(6): 331–339.
- Magouz, F.I., Mahmoud, S.A., El-Morsy, R.A.A., Paray, B.A., Soliman, A.A., Zaineldin, A.I., & Dawood, M.A.O. (2021). Dietary menthol essential oil enhanced the growth performance, digestive enzyme activity, immune-related genes, and resistance against acute ammonia exposure in Nile tilapia (*Oreochromis niloticus*). *Aquaculture*, 530: 735944.
- Mohammed, H.H., & Arias, C.R. (2016). Protective efficacy of *Nigella sativa* seeds and oil against Columnaris disease in fishes. *Journal of Fish Diseases*, 39(6): 693–703.
- Öz, M., Dikel, S., & Durmus, M. (2018). Effect of black cumin oil (*Nigella sativa*) on the growth performance, body composition, and fatty acid profile of rainbow trout (*Oncorhynchus mykiss*). *Iranian Journal of Fisheries Sciences*, 17(4): 713–724.
- Öz, M., Üstüner, E., & Bölükbaş, F. (2024). Effects of dietary black cumin (*Nigella sativa* L.) oil on growth performance, hemato-biochemical, and histopathology of cypermethrin-intoxicated Nile tilapia (*Oreochromis niloticus*). *Journal of the World Aquaculture Society*, 55(1): 273–288.
- Rahim, M.A., Shoukat, A., Khalid, W., Ejaz, A., Itrat, N., Majeed, I., Koraqi, H., Imran, M., Nisa, M. U., Nazir, A., Alansari, W. S., Eskandrani, A. A., Shamlan, G., & AL-Farga, A. (2022). A narrative review on various

oil extraction methods, encapsulation processes, fatty acid profiles, oxidative stability, and medicinal properties of black seed (*Nigella sativa*). *Foods*, 11(18).

Reverter, M., Sarter, S., Caruso, D., Avarre, J., Combe, M., Peppey, E., Pouyaud, L., Vega-heredía, S., Verdal, H. D., & Gozlan, R.E. (2020). Aquaculture at the crossroads of global warming and antimicrobial resistance. *Nature Communications*, 1870: 1–8.