

# Yellow mealworm (*Tenebrio molitor*) as an alternative protein source in fish feed

## Abstract

The rapid growth of aquaculture has increased the demand for fish meal and fish oil, essential components of fish feed, leading to higher production costs due to dwindling global supplies. As the industry seeks sustainable alternatives, insects, particularly the yellow mealworm (*Tenebrio molitor*), are emerging as a viable protein source. With a nutritional profile comparable to fish meal and low environmental impact, insects offer an efficient and economical solution for feed production. The European Union's approval of mealworms for both animal feed and human consumption highlights their potential to support food security and environmental sustainability amidst rising global protein demands.

**Keywords:** aquaculture, fish meal, yellow mealworm, environmental impact, animal feed

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**Seval Dernekbaşı, Bahadır Tunahan Karadayi**  
Sinop University, Fisheries and Aquaculture Faculty, Aquaculture Department, Türkiye

**Correspondence:** Seval Dernekbaşı, Sinop University, Fisheries and Aquaculture Faculty, Aquaculture Department, Sinop, Türkiye, Email [sevalyaman@hotmail.com](mailto:sevalyaman@hotmail.com)

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## Introduction

There is an increasing trend and demand for aquaculture in the world for various reasons and a rising increase in aquaculture. The rapid development of aquaculture in general and fish farming, in particular, has led to an increase in the demand for fish meal and fish oil, which are the basic feed ingredients in aquaculture. The most important factor affecting efficiency and cost in aquaculture is feed. Fish meal is generally used as the basic protein source in fish feed. Fish meal is the most important and indispensable protein source for fish feed due to its high protein content, balanced amino acid composition and deliciousness by fish.<sup>1</sup> Since fish meal is used as a protein source not only in fish feed but also in animal feed, it leads to significant increases in feed production costs. In this case, while the area of use of fish meal is increasing, its amount worldwide is decreasing.

In recent years, this situation in fish meal and oil has directed sector stakeholders to alternative protein sources for use in fish feed in the aquaculture sector.<sup>2,3</sup> To create a sustainable, economical mixed feed industry, finding alternative, healthy sources that can meet the amino acid needs of fish in fish feed is also important in terms of reducing inputs in the sector and contributing to the country's economy.<sup>4</sup> Insects are shown as one of the important alternative animal protein sources instead of fish meal in fish feed with their features such as having protein and fat ratios similar to those in fish meal in fish feed and being an easily and cheaply accessible source. They are also known as the natural source of many amino acids and phosphorus and constitute the natural food of many fish species in nature.<sup>5,6</sup>

Insects are promising in animal nutrition due to their short generation time, low carbon emission in their production, easy and large production quantities and low production costs. Experimental studies show that insects can convert 8-9% of low-quality protein food waste into 44-61% quality protein in controlled conditions over 3-4 months. The use of insects in fish feed, which is necessary for sustainable farming, was made free by the decision of the European Union on May 24, 2017, and they started to be used as feed raw material in the aquaculture sector (Commission Regulation, 893/2017).

Aquaculture has reached its current point with the elimination of all unknowns regarding the reproductive biology of commercially important species. In recent years, the adaptation of alternative species

to farming conditions and their addition to production are indicators that the sector will expand in the coming years. Among insects, the yellow mealworm (*Tenebrio molitor*) stands out as a sustainable alternative to animal-based protein sources suitable for mass production. In addition, it can be an important raw material in animal nutrition due to its features such as being a species that can be easily grown in a laboratory environment, having low production and feeding costs, and being able to be produced in large quantities per unit area, as well as being able to convert low-protein plant materials into high-quality protein. The European Union (EU) allowed the use of yellow mealworms for human consumption in 2021, and the European Food Safety Authority (EFSA) conducted a safety assessment on yellow mealworms in 2021, as a result of this assessment, it was decided that dried yellow mealworms were safe. This decision made yellow mealworms the first insect species permitted to be used as food in the EU. Yellow mealworms have begun to be used in food products after the EU approved them in 2021. They are especially found in products containing insect-based proteins. As interest in using insects as a protein source increases in Europe, mealworms are offered to consumers in the form of protein bars, baked goods, snacks, and flour.

The world population is increasing rapidly and is expected to exceed 9 billion by 2050. This will naturally increase the need for protein in the future. The yellow mealworm, which is among the edible insects, can have an important place in both human and animal nutrition in the future, both in terms of nutritional value and as a protein source that supports environmental sustainability. In addition, it is expected that this alternative protein source, whose production is increasing, will make significant contributions to food security and nutritional diversity with wider acceptance.

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## Conflicts of interest

The authors declare that there are no conflicts of interest.

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