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Enhancing Aquaculture Sustainability: The Role of Rapeseed Meal as a Fishmeal Alternative

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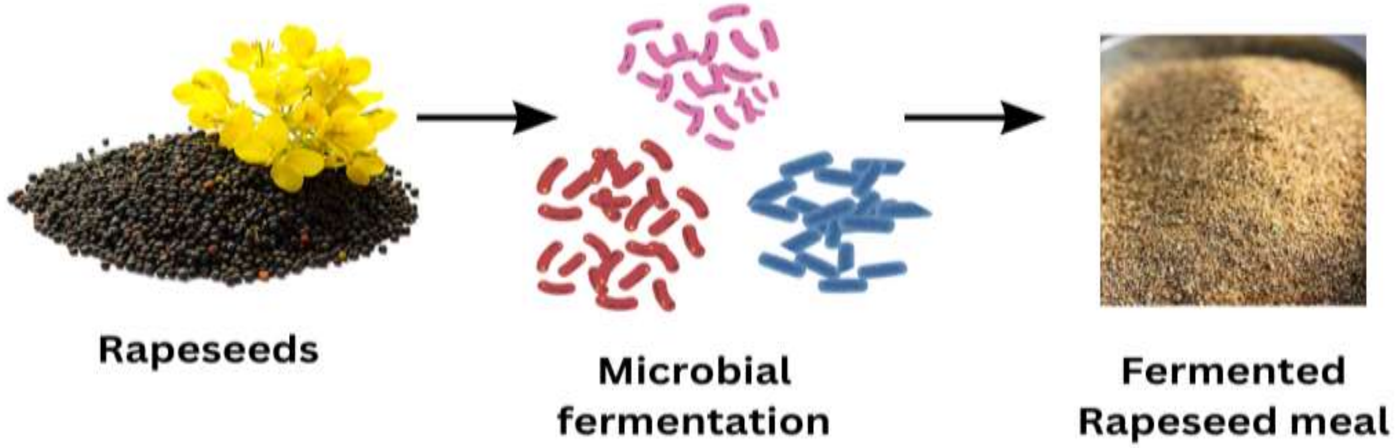
SUMMARY

Rapeseed meal (RM) is now the second most traded protein source after soybean meal, containing 32–45% protein with a favorable amino acid composition. While rapeseed protein is lower in lysine than soybean protein, it is richer in sulfur-containing amino acids. Common rapeseed products include cakes, meals, concentrates, and isolates, produced through various processing methods. Despite its nutritional benefits, RM contains anti-nutritional factors (ANFs) such as sinigrin and phenolic compounds that can adversely affect fish growth and health when included in large amounts. Efforts to enhance the quality of rapeseed meal have led to various processing techniques; however, these often face challenges like protein loss and high costs. Recently, microbial fermentation has been identified as an effective method to improve the nutritional quality of rapeseed products by reducing ANFs and enhancing antioxidant properties. Feeding trials have shown that rapeseed protein concentrates can completely replace fishmeal in diets for species like rainbow trout without compromising growth performance, indicating its potential as a sustainable alternative in aquaculture feeds.

INTRODUCTION

Aquaculture has played a crucial role in addressing the rising demand for high-quality food by significantly boosting global fish production. Although the use of fishmeal in aqua feeds has notably declined in recent years, the rapid growth of aquaculture has still driven a demand for fishmeal that cannot be sustainably met through the harvesting of small pelagic fish. Therefore, identifying and adopting alternatives to fishmeal in aqua feeds has become essential. Various plant proteins have been assessed as alternatives to fishmeal, with rapeseed protein emerging as a particularly valuable option for fishmeal-free aqua feeds. Rapeseed is widely available globally and offers one of the most balanced amino acid profiles among plant-based protein sources, making it a promising option for sustainable aquaculture.



Rapeseed meal

Rapeseed meal (RM) has become the second most traded protein component after soybean meal due to a steady growth in production over the past few years. RM contains a high protein content (32–45% dry matter) with a well-balanced amino acid profile. Rapeseed protein is lower in lysine than soybean protein but richer in sulfur-containing amino acids. The most common rapeseed protein products include cakes, meals, concentrates, and isolates. Press cakes are produced through seed pre-treatment and mechanical oil removal, while rapeseed meal is obtained by further solvent extraction and desolventisation. Additional processes such as extraction, filtration, sieving, or precipitation purify these products into protein concentrates or isolates. However, the presence of anti-nutritional factors such as sinigrin and phenolic compounds in rapeseed cake and meal and a deficiency in certain amino acids like lysine can lead to impaired fish growth and health issues when significant amounts are incorporated into aqua feeds. The primary negative effects of these ANFs include reduced palatability, lower feed intake, and poor digestibility. Various processing techniques have been used to enhance the quality of rapeseed meal (RM), but they often face challenges such as protein loss, high costs, limited commercial feasibility, and environmental concerns. Microbial fermentation methods have emerged as effective alternatives, offering benefits such as improved biological detoxification, enhanced nutritional quality, and better antioxidant properties.

Fermentation methods of Rapeseed meal

Microbial fermentation of Rapeseed meal using bacteria and yeast can reduce ANFs and phytic acid levels and increase the relative levels of crude protein and minerals.

Microbial fermentation methods of Rapeseed meal

1. Bacteria fermentation

The fermentation process involved using microorganisms, specifically *Lactobacillus fermentum* and *Bacillus subtilis*. A mixed liquid culture with a pH of 6.5, containing approximately 5 log cfu/ml of each microorganism in a 1:1 ratio, was prepared. This culture was then combined with a basal substrate consisting of 95% rapeseed, 4% wheat bran, and 1% brown sugar in a 3:1 ratio. The mixture was packaged in a newly developed multi-layer polyethylene bag with a 25 kg capacity, equipped with a one-way valve to release the carbon dioxide produced during fermentation. During the initial fermentation phase, *Bacillus subtilis* rapidly consumed the oxygen inside the bag and produced significant amounts of carbon dioxide. The valve allowed the carbon dioxide to escape while preventing outside air from entering, creating an anaerobic environment ideal for *Lactobacillus fermentum* to thrive. The fermentation process was maintained at 30 ± 2°C for 30 days. Subsequently, the samples were dried at 50 to 60°C for 3 days.

2. Yeast fermentation

Yeast, especially Saccharomyces cerevisiae, is a readily available, cost-effective aquafeed ingredient. It has been widely used to reduce anti-nutritional factors by fermenting and degrading phytic acid with phytase. Additionally, yeast fermentation can boost crude protein and mineral levels in plant-based meals. Using fermented rapeseed meal (FRM) as a fish meal substitute in aquafeeds has the potential to significantly lower feed costs. The fermentation process involves the following steps: (1) preparation of inoculum medium and fermentation medium; (2) inoculation of medium with yeasts; (3) inoculation of fermentation medium with the inoculum obtained in step 2, followed by incubation at 24 h, 130 rpm and 27 ◦C; (4) inoculation of RSM with the inoculum obtained in step 3, followed by solid-state fermentation in plastic bags. Two periods of fermentation (24 h, 72 h) were tested, according to the increase in active compound concentration; and (5) processing of FRSM by grinding (40-mesh sieve) for related index determination. After fermentation, the samples were dried in the oven at 60 ◦C.

CONCLUSION

Fermentation serves as a vital method for enhancing the nutritional quality of both conventional and unconventional aquafeed ingredients. Research indicates that fermented feeds positively influence the gastrointestinal tract (GIT) ecosystems and morphology, as well as improve growth performance and feed efficiency in aquatic animals. The dietary tolerance levels for anti-nutritive substances in rapeseed protein products have been identified in various fish species, with approximate thresholds of 0.7 µmol/g for glucosinolates, 0.4% for phytic acid, 0.5% for proteinase inhibitors, 0.2% for tannins, and 3% for crude fiber. However, the precise effects and mechanisms of these anti-nutritive substances remain unclear, and further investigation to establish exact tolerance limits. Additionally, factors such as amino acid composition, physical properties of the feed, and lesser-known compounds may also influence fish growth performance. Future research should focus on these aspects, particularly with highly purified rapeseed protein products that contain minimal anti-nutritive factors. Despite the challenges posed by these substances, rapeseed proteins hold significant promise as an alternative to fishmeal in aquafeeds, and their nutritional value could potentially be enhanced to meet the standards required for various fish species.

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