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Enhancing Fish Fingers with Moringa: A Nutritious Turn to Seafood Convenience Foods

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In recent years, consumers have become increasingly interested in foods that are not only tasty and convenient but also nutritious and beneficial to health. This shift in dietary preferences has encouraged food scientists and the seafood industry to develop innovative products that combine nutritional value with consumer appeal. Among such products, fish-based convenience foods have gained significant attention due to their rich protein content, essential fatty acids, vitamins, and minerals. Fish fingers, in particular, have emerged as one of the most popular ready-to-cook seafood products because of their attractive taste, ease of preparation, and suitability for people of all age groups.

Fish fingers are battered and breaded products prepared from fish mince or muscle, shaped into convenient portions and often pre-fried before storage. Several studies have demonstrated that fish fingers can be successfully produced from a variety of fish and shellfish species while maintaining desirable sensory and nutritional qualities during storage (Cakli et al., 2005; Praneetha et al., 2015; Mangale et al., 2024). These products offer an effective way to utilize underutilized fish species and low-value seafood resources, thereby reducing waste and enhancing the economic value of fisheries resources. Furthermore, the growing demand for convenience foods has created opportunities to improve traditional fish finger formulations by incorporating functional ingredients that provide additional health benefits.

One such promising ingredient is *Moringa oleifera*, commonly known as the drumstick tree or "miracle tree." Moringa leaves are recognized worldwide for their exceptional nutritional composition, containing high levels of protein, dietary fiber, vitamins, minerals, and bioactive compounds such as flavonoids, phenolics, and antioxidants (Mensah et al., 2012; Singh et al., 2013). These compounds have been associated with numerous health-promoting properties, including antioxidant, antimicrobial, anti-inflammatory, and immune-supporting effects (Bashir et al., 2016). Because of these attributes, moringa leaf powder has attracted considerable interest as a natural functional ingredient for food fortification.

Researchers have explored the incorporation of moringa leaf powder into various meat and fish products to enhance their nutritional profile. Studies have shown that moringa supplementation can increase protein, mineral, and antioxidant content while contributing to the development of healthier food products (Solichah et al., 2021; Haruni et al., 2024). Although excessive inclusion may affect colour, flavour, and texture, carefully optimized levels have been found to maintain consumer acceptability while significantly improving nutritional quality.

The integration of nutrient-rich moringa leaf powder into fish fingers therefore represents a promising strategy to create value-added seafood products that are both nutritious and appealing. Such innovations can contribute to improved dietary quality, promote the utilization of fisheries resources, and support the growing demand for functional foods that combine convenience with health benefits.

Fish Fingers: A Popular Seafood Convenience Product

The demand for ready-to-cook and ready-to-eat seafood products has increased significantly due to changing lifestyles and growing awareness of the health benefits associated with fish consumption. Among various value-added seafood products, fish fingers are widely appreciated because of their convenience, appealing taste, and high nutritional value. Prepared from minced fish coated with batter and breadcrumbs, fish fingers provide a rich source of high-quality protein, essential fatty acids, vitamins, and minerals.

Several researchers have reported successful production of fish fingers from different fish species such as sardine, whiting, pike perch, rohu, Bombay duck, and mackerel. These studies demonstrated that fish fingers possess desirable sensory qualities, including flavour, texture, colour, and overall acceptability, making them attractive to consumers across all age groups (Cakli et al., 2005; Praneetha et al., 2015; Alkuraieef et al., 2020). Furthermore, shrimp-based fish fingers developed from kiddi shrimp (*Parapenaeopsis stylifera*) have shown promising nutritional and sensory characteristics, highlighting the potential of diversified seafood resources in product development.

Quality and Shelf-Life of Fish Fingers

The quality of fish fingers during storage is an important factor influencing consumer acceptance and marketability. Various studies have investigated chemical, microbiological, and sensory changes occurring during refrigerated and frozen storage. Results indicate that moisture and protein contents generally decrease over time, while lipid oxidation indicators such as peroxide value (PV), thiobarbituric acid (TBA), and free fatty acids (FFA) tend to increase.

Despite these changes, properly processed and stored fish fingers remain microbiologically safe and sensorially acceptable for extended periods. For example, sand smelt fish fingers remained acceptable during six months of frozen storage, while Bombay duck fish fingers retained desirable quality for up to 15 days under refrigerated conditions. Similarly, frozen fish fingers prepared from common carp and mackerel maintained acceptable sensory scores throughout storage (Izci et al., 2011; Jeyakumari et al., 2017). These findings emphasize the need for natural ingredients that can further improve product stability and nutritional quality.

Moringa: A Nutritional Powerhouse

Moringa oleifera, commonly known as the drumstick tree, has gained worldwide recognition as a functional food ingredient due to its exceptional nutritional composition. The leaves are rich in proteins, dietary fibre, vitamins, minerals, and numerous bioactive compounds such as flavonoids, phenolics, alkaloids, and antioxidants.

Studies have shown that moringa leaf powder contains substantial amounts of calcium, iron, potassium, magnesium, vitamin A, vitamin C, and essential amino acids. Besides its nutritional benefits, moringa possesses antimicrobial, antioxidant, anti-inflammatory, and immunomodulatory properties that contribute to overall health and wellbeing (Mensah et al., 2012; Bashir et al., 2016; Rajput et al., 2017). These characteristics make moringa an attractive natural ingredient for developing nutrient-enriched food products.

Moringa as a Functional Ingredient in Fish and Meat Products

The incorporation of moringa leaf powder into fish and meat products has been extensively explored to enhance nutritional quality. Research on fish nuggets, fish balls, milkfish meatballs, chicken meatballs, and pork balls has demonstrated that moringa supplementation can significantly increase protein, mineral, fibre, and antioxidant contents.

Solichah et al. (2021) reported that fish nuggets fortified with moringa exhibited higher protein and mineral levels, while Haruni et al. (2024) observed increased calcium and iron contents in mackerel nuggets supplemented with moringa flour. Similarly, studies on fish balls and meatballs showed improvements in nutritional value and antioxidant activity following moringa incorporation (Nuryahyani et al., 2022; Rasak et al., 2023). These findings indicate that moringa can serve as an effective functional ingredient for improving the nutritional profile of seafood products.

Balancing Nutrition and Consumer Acceptability

While moringa enhances the nutritional quality of food products, its incorporation must be carefully optimized to maintain consumer acceptability. Several studies have reported that excessive levels of moringa may negatively affect colour, flavour, aroma, and texture due to its characteristic green colour and herbal taste.

Research involving fish nuggets, meatballs, and fish balls has consistently shown that moderate levels of moringa supplementation provide the best balance between nutritional enhancement and sensory quality. Products containing low to moderate levels of moringa received favourable scores for taste, texture, and overall acceptability, whereas higher inclusion levels often resulted in reduced consumer preference (Evivie et al., 2015; Minantyo et al., 2019; Augustina et al., 2023). Therefore, optimization of moringa concentration is essential for developing commercially successful functional seafood products.

Future Prospects for Moringa-Enriched Fish Fingers

The integration of moringa leaf powder into fish fingers offers a promising opportunity to create nutrient-dense, functional seafood products that align with modern consumer demands. By combining the high-quality protein and omega-3-rich nutrients of fish with the vitamins, minerals, and antioxidants present in moringa, manufacturers can develop products that provide both nutritional and health benefits.

Moreover, the use of moringa as a natural ingredient supports the growing trend toward clean-label foods and reduces dependence on synthetic additives. As research continues to optimize formulations and processing techniques, moringa-enriched fish fingers have the potential to become an important category of functional seafood products, contributing to improved nutrition, food security, and sustainable utilization of aquatic resources.

Summary

The article explores the development of moringa-enriched fish fingers as a functional seafood product that combines convenience with enhanced nutrition. Fish fingers are valued for their high-quality protein and consumer appeal, while *Moringa oleifera* leaf powder contributes proteins, vitamins, minerals, dietary fibre, and antioxidants. Research indicates that optimized moringa incorporation improves nutritional quality without compromising sensory characteristics. This innovation promotes healthier seafood products, supports sustainable utilization of aquatic resources, and addresses the growing consumer demand for clean-label, nutrient-rich convenience foods.

Conclusion

Fish fingers have emerged as one of the most popular value-added seafood products due to their convenience, nutritional value, and consumer acceptability. Research conducted on various fish and shellfish species has demonstrated that fish fingers can be successfully developed with desirable sensory, nutritional, and storage characteristics. At the same time, increasing consumer demand for healthier foods has encouraged the incorporation of functional ingredients that enhance the nutritional profile of seafood products. Among these ingredients, *Moringa oleifera* leaf powder stands out as a rich source of proteins, vitamins, minerals, dietary fibre, and natural antioxidants. Numerous studies have shown that moringa supplementation can improve the nutritional quality, antioxidant capacity, and health-promoting properties of fish and meat products. Although excessive levels may influence

colour, flavour, and texture, optimized incorporation levels can achieve a balance between enhanced nutrition and consumer preference. The primary purpose of combining moringa with fish fingers is to develop a functional seafood product that delivers superior nutritional benefits while maintaining desirable sensory qualities. Such products can contribute to improved dietary intake, better public health, and increased utilization of aquatic resources. Looking ahead, future research should focus on optimizing moringa incorporation levels, evaluating long-term storage stability, and exploring innovative processing technologies to improve product quality. The development of moringa-enriched fish fingers represents a promising avenue for creating sustainable, nutritious, and consumer-friendly seafood products that meet the evolving demands of modern food systems.

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