Article Id
AL04468

FISH OIL TO PHARMA: THE JOURNEY OF MARINE BIOACTIVES

[1]Praveenkumar Pandiyan* and [2]Ajeet Soni

Email

praveenkumar@tnfu.ac.in

[1]Department of Fish Processing Technology, Dr. MGR Fisheries College and Research Institute, Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Nagapattinam, Tamil Nadu, India

[2]Department of Fish Processing Technology, College of Fisheries Science & Research Centre, Etawah, Uttar Pradesh, India

The marine environment, covering more than 70% of the Earth's surface, is an immense and largely untapped source of bioactive compounds. These compounds — derived from fish, algae, seaweeds, crustaceans, and marine microbes — hold great promise in addressing many of today's health challenges. For centuries, humans have consumed seafood for its flavor and nourishment. But recent research highlights the ocean's hidden potential: the production of natural molecules with antimicrobial, anticancer, anti-inflammatory, and antioxidant effects. As we navigate the 21st century, the intersection of marine biology, nutrition, and pharmaceutical sciences is revealing a new frontier — one where marine bioactives evolve from dietary supplements into targeted therapeutic agents.

From the Ocean to Our Plate: Nutritional and Functional Foundations

A. Richness of Marine Lipids

Marine lipids, particularly from oily fish like salmon, tuna, and sardines, are packed with omega-3 polyunsaturated fatty acids (PUFAs) like EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid). These fats are essential to human health and cannot be synthesized endogenously.

B. High-Quality Proteins and Micronutrients

Fish offer a complete profile of amino acids and are rich in micronutrients including iodine, calcium, selenium, vitamin D, and B-complex vitamins. Even small indigenous species like *Amblypharyngodon mola* contain retinol and dihydro-retinol, essential for vision and immunity.

C. Cardiovascular and Cognitive Health

Numerous clinical trials and WHO recommendations support the regular intake of fish to prevent cardiovascular diseases, reduce triglycerides, and improve brain function and mood stability.

Marine Bioactive Compounds: Nature's Hidden Pharmaceuticals

A. Fatty Acids and Beyond

While omega-3 PUFAs have gained attention for heart and brain health, marine organisms also produce unique lipid classes such as methoxylated, halogenated, and branched fatty acids, especially in invertebrates like sponges and gorgonians. Some of these have antimicrobial, immunomodulatory, and even antitumoral properties.

B. Antioxidants from the Sea

Compounds such as astaxanthin (from crustaceans), fucoxanthin (from brown seaweed), and phenolic compounds (from algae and cyanobacteria) help neutralize oxidative stress, which contributes to aging, cancer, and neurodegenerative disorders.

C. Marine Polysaccharides

Algal polysaccharides like alginates, fucoidans, and carrageenans exhibit anti-viral, anticoagulant, and immune-boosting properties. These are increasingly used in dietary supplements, wound healing materials, and anti-obesity formulations.

Marine Bioactive Peptides (MBPs): Tiny Molecules, Massive Impact

A. Peptides with Potency

Enzymatic hydrolysis of fish muscle, skin, and viscera produces peptides that serve as natural inhibitors for ACE (angiotensin-converting enzyme), demonstrating antihypertensive effects. Others have antioxidant, antimicrobial, and opioid-like actions.

B. Sources and Extraction

Marine bacteria, microalgae, and fungi also synthesize bioactive peptides. These are extracted using green biotechnological approaches including enzyme-assisted extraction, membrane filtration, and chromatography.

C. Market and Regulation

While MBPs are not yet widely used in mainstream pharmaceuticals, the nutraceutical industry is actively commercializing marine peptides for use in protein drinks, functional snacks, and elderly nutrition formulations.

From Fish Oil to Clinical Pills: Functional Foods Meet Pharmaceuticals

A. Nutraceuticals and Functional Foods

Marine-derived supplements like fish oil capsules, krill oil, and algae-based omega-3s are widely available. These are not only used for cardiovascular wellness but also increasingly for sports nutrition and eye health.

Fig 1. Fish Oil Capsules

B. Marine Drugs and Clinical Trials

FDA-approved marine-derived drugs such as Lovaza and Vascepa (both purified omega-3 formulations) are prescribed to treat high triglyceride levels. Additionally, several marine compounds — including those from cone snails and sea sponges — are in clinical or pre-clinical stages for cancer and neuropathic pain.

C. Emerging Trends

Nanoencapsulation, emulsion technology, and bio-delivery systems are being developed to enhance the absorption and effectiveness of marine bioactives.

Sustainability, Circular Economy, and the Blue Biotech Revolution

A. From Waste to Wealth

Fish processing byproducts (heads, skin, bones, viscera) are being upcycled into hydrolyzed protein powders, oils, collagen, gelatin, and bioactive peptides, reducing environmental load and creating value-added products.

B. Role in Sustainable Development Goals (SDGs)

Marine bioactives directly support SDG 2 (Zero Hunger), SDG 3 (Good Health), and SDG 12 (Responsible Consumption and Production). Integrating marine bioproducts into local diets can address malnutrition and food insecurity, particularly in coastal and island communities.

C. Eco-Friendly Technologies

Modern extraction processes such as subcritical water extraction, enzyme-assisted extraction, and membrane technologies align with green chemistry principles, making the production of bioactives more sustainable.

Future Prospects and Research Frontiers

A. Marine Bioprospecting

Deep-sea organisms, extremophiles, and marine symbionts offer immense untapped potential for discovering new antibiotics, anticancer agents, and metabolic modulators.

B. Interdisciplinary Collaboration

The journey from fish to pharma requires a collaborative ecosystem — involving fisheries scientists, marine ecologists, biotechnologists, nutritionists, and pharmaceutical developers.

C. Challenges Ahead

Issues such as standardization, clinical validation, regulatory approval, and consumer acceptance remain barriers that must be addressed with science-based policies and public education.

Conclusion: A Sea of Possibilities

The story of marine bioactives is not just about fish oil or seaweed capsules. It's about how the ocean's bounty — once seen as mere food — is transforming into a robust platform for health, wellness, and therapeutics. With continued research, innovation, and sustainable harvesting, the marine realm could hold the keys to solving some of the greatest health challenges of our time.

References

Bergé, J. P., & Barnathan, G. (2005). Fatty acids from lipids of marine organisms: molecular biodiversity, roles as biomarkers, biologically active compounds, and economical aspects. *Marine biotechnology I*, 49-125.

Ghosh, S., Sarkar, T., Pati, S., Kari, Z. A., Edinur, H. A., & Chakraborty, R. (2022). Novel bioactive compounds from marine sources as a tool for functional food development. *Frontiers in Marine Science*, *9*, 832957.

Ashraf, S. A., Adnan, M., Patel, M., Siddiqui, A. J., Sachidanandan, M., Snoussi, M., & Hadi, S. (2020). Fish-based bioactives as potent nutraceuticals: Exploring the therapeutic perspective of sustainable food from the sea. *Marine drugs*, *18*(5), 265.

Ahmed, I., Asgher, M., Sher, F., Hussain, S. M., Nazish, N., Joshi, N., ... & Iqbal, H. M. (2022). Exploring marine as a rich source of bioactive peptides: Challenges and opportunities from marine pharmacology. Marine drugs, 20(3), 208.