

Insects, Algae, and Beyond: The New Ingredients Powering Aquafeeds

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A Blue Revolution Needs a Feed Revolution

As global demand for seafood rises, aquaculture must scale sustainably. However, the over-reliance on fish-meal and fish oil is creating ecological strain. Innovators are turning to unconventional yet sustainable ingredients from insects to algae and fermented proteins to revolutionize fish and shrimp feed.

1. Insects: The High-Protein Powerhouse

Insects particularly black soldier fly (BSF) larvae have emerged as one of the most promising sustainable protein sources in aquafeeds. These tiny organisms thrive on organic waste, converting it into nutrient-dense biomass in a matter of days. With a crude protein content of 40–60% and rich in essential amino acids, fats, and micronutrients, BSF meal is an effective substitute for traditional fishmeal.

Nutritional Highlights:

- High protein and fat content
- Rich in lauric acid (antimicrobial properties)
- Excellent amino acid profile for finfish and shrimp

Environmental Benefits:

- Grown on food and agricultural waste
- Requires far less land and water than soy or fish-meal
- Supports circular bioeconomy and waste valorization

Numerous studies have shown that BSF larvae meal can replace up to 50% of fishmeal in tilapia, catfish, and shrimp diets without compromising growth, feed conversion ratio (FCR), or health.

2. Algae and Seaweed: Ocean's Functional Feed

From microscopic microalgae to macro-scale seaweeds, marine flora is redefining the nutritional foundation of modern aquafeeds. These oceanic ingre-

dients are rich in omega-3 fatty acids (DHA, EPA), antioxidants, vitamins, and bioactive compounds that support fish health, growth, and stress resistance.

Nutritional Highlights:

- Microalgae like Schizochytrium and Chlorella are rich in DHA and essential amino acids
- Seaweeds such as Ulva, Gracilaria, and Sargassum provide minerals, polysaccharides, and immunity-boosting compounds
- Improve pigmentation, gut health, and reproductive performance

Environmental Benefits:

- Grown without freshwater, fertilizers, or land
- Sequester carbon and improve coastal water quality
- Ideal for integration with mariculture and coastal SHG enterprises

Algal oils are now commercially replacing fish oil in salmon and trout diets with no adverse impact on growth or taste. Red and green seaweed extracts have shown antibacterial and immunostimulant effects in shrimp and carp culture.

3. Fermented Proteins: Single-Cell Innovations

As aquaculture seeks stable, scalable protein alternatives, single-cell proteins (SCPs) produced through fermentation of bacteria, yeasts, fungi, and algae are emerging as game-changers. These proteins are grown using industrial fermentation technology, often utilizing methane, ethanol, or food processing waste as feedstock.

Nutritional Highlights:

- Crude protein content between 60–75%
- Rich in nucleotides, B-complex vitamins, and functional compounds
- Highly digestible with low anti-nutritional factors.

Environmental Benefits:

- Utilizes waste carbon gases or agro-industrial residues
 - Requires no arable land or freshwater
 - Produces consistent quality protein all year round
- Studies on species like barramundi, tilapia, and shrimp show that SCPs such as those from *Methylococcus capsulatus*, *Corynebacterium glutamicum*, or *Candida*



Picture 1: Showing black soldier fly larvae, spirulina, fermenters, and seaweeds on racks

utilis can replace up to 80% of fishmeal without affecting performance. They also improve gut microbiota and reduce nitrogen waste.

4. Agri-Food Waste: From Trash to Feed

In the quest for sustainable aquafeeds, agri-food waste once seen as valueless is now being upcycled into high-nutrition, low-cost feed ingredients. From fruit pomace and vegetable peels to spent grain and bakery waste, these byproducts are being fermented, dried, or pelletized to support fish and shrimp growth.

Nutritional Highlights:

- Rich in dietary fiber, residual carbohydrates, and moderate protein
- Valuable micronutrients from peels and pulp (e.g., potassium, polyphenols)
- Can serve as prebiotics to support gut health

Circular Economy Benefits:

- Reduces landfill and greenhouse gas emissions
- Creates value from perishable food chain losses
- Empowers coastal communities with micro-feed units

5. Functional Additives from Nature

As antibiotic resistance and disease outbreaks challenge aquaculture, the spotlight is shifting to natural functional additives that not only support fish growth

but also enhance immunity, gut health, and resilience to stress. These ingredients, derived from plants, microbes, and marine sources, are being blended into modern aquafeeds as natural immunostimulants, probiotics, and alternatives to antibiotics.

Key Categories of Functional Additives:

1. **β-glucans** (from yeast/mushrooms)
 - Activate non-specific immunity in shrimp and fish
 - Reduce mortality under *Vibrio* and *Aeromonas* challenges
2. **Phytogenic extracts** (garlic, neem, turmeric, moringa)
 - Antibacterial, antifungal, antioxidant properties
 - Improve digestion and FCR
3. **Probiotics and prebiotics** (e.g., *Bacillus subtilis*, inulin)
 - Balance gut microbiota
 - Improve nutrient uptake and reduce ammonia stress
4. **Phage-based biocontrol**
 - Target specific fish pathogens like *Vibrio harveyi* without harming beneficial bacteria
 - Scalable for hatchery and pond use

Sustainability Angle:

- Reduces reliance on chemicals and antibiotics
- Environmentally safe, residue-free, and export-friendly
- Enables organic aquaculture certification for high-value markets

Conclusion: A Feed System Fit for the Future

As aquaculture feeds billions, future feeds must be sustainable and responsible. Insect meal, algae, SCPs, and food-waste proteins are driving the transformation of aquafeeds into climate-smart solutions for global food security.

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