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Edible Insects: A Sustainable Nutritional Resource for the Future Food System

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Abstract: ***Edible insects are gaining global attention as sustainable and nutrient-dense food sources. Traditionally consumed in Africa, Asia, and Latin America, insects provide high-quality protein, essential fatty acids, vitamins, and minerals while requiring minimal resources to produce. With the rising global population and increasing demand for animal-derived proteins, edible insects present a viable alternative to conventional livestock. Modern insect farming technologies, processing techniques, and commercialization strategies are revolutionizing their integration into mainstream food systems. This review summarizes recent findings (2020–2025) on the nutritional composition, bioactive compounds, processing innovations, safety aspects, and sustainability of edible insects, highlighting their potential contribution to food security and human health.***

Keywords: Edible insects, sustainable nutrition, insect farming, food security, human health

1. Introduction

Global food demand is projected to rise by over 50% by 2050, driven by population growth and urbanization. Edible insects have emerged as a promising solution to enhance food and feed security while minimizing environmental impacts. More than 2,000 species are currently identified as edible, and their use spans from traditional diets to commercialized products such as protein powders and snacks. Recent research emphasizes the role of insect-derived proteins, peptides and lipids as functional food ingredients offering antioxidant, anti-inflammatory and immunomodulatory benefits.

2. Historical Background of Entomophagy

Entomophagy the consumption of insects has been part of human diets since prehistoric times. Archaeological evidence and paleodiet studies confirm that early humans relied on termites, ants, and beetle larvae as essential food sources. Despite being culturally accepted in tropical regions, psychological and cultural biases have limited its adoption in Western societies. Educational awareness and strict regulatory frameworks under the FAO, EFSA, and Codex Alimentarius are gradually improving consumer acceptance.

1) Nutritional and Functional Composition

Insects contain 40–75% protein (dry weight), with all essential amino acids **(1).** Cricket and mealworm proteins demonstrate digestibility comparable to milk casein and soy protein. Bioactive peptides from Tenebrio molitor and Gryllus bimaculatus show antihypertensive and antioxidant activities **(2).** Insect lipids comprise 10–50% of dry mass, dominated by unsaturated fatty acids, including omega-3 and omega-6. Studies in 2023–2024 reported that Hermetia illucens larvae oils can be used as substitutes for plant oils in bakery and dairy applications. Edible insects are rich in vitamin B12, riboflavin, iron, zinc, and calcium—often surpassing levels in beef and poultry.

2) Processing and Preservation Technologies

Recent advancements in edible insect processing such as freeze-drying, blanching, vacuum packaging and microwave drying help retain nutritional quality while ensuring microbial safety **(3).** Novel technologies like high-pressure processing (HPP) and supercritical CO_2 extraction are being applied to obtain insect oils and proteins for functional food use. Long-term storage stability improves through vacuum-sealed and refrigerated systems, reducing oxidation and microbial degradation.

3) Insect Farming Innovations

Controlled-environment insect farming optimizes humidity, temperature, and feed efficiency **(4).** Using organic waste substrates, such as fruit peels and grains, reduces production costs and environmental footprint. Automation and AI-based monitoring systems (2024) have enhanced large-scale production in Europe and Asia.

4) Commercialization and Consumer Acceptance

The edible insect industry exceeded USD 1.5 billion in 2024, with key markets in Thailand, the Netherlands, and the U.S **(5)**. Products include protein powders, insect-based pasta, snack bars, and meat analogs. Consumer studies show that incorporating insect flour (≤10%) into baked products significantly improves nutrition without altering sensory acceptability.

5) Environmental and Socioeconomic Benefits

Insect farming emits up to 100 times less greenhouse gas than cattle rearing and requires 80% less land and water **(6)**. It provides rural employment opportunities, supports circular economy models through organic waste recycling, and enhances food resilience against climate change.

6) Health Benefits and Safety Concerns

Edible insects contribute to combating malnutrition, especially among children and low-income populations (7). However, allergenicity (cross-reactivity with crustaceans), heavy metal accumulation and microbial contamination remain concerns. Adherence to EU Novel Food Regulation

(2015/2283) and FSSAI food safety guidelines (2023 update) ensures safe production and labeling.

3. Future Prospects

Insect biotechnology can enable the extraction of chitin, chitosan, and peptides for nutraceutical and pharmaceutical uses (2). Integrating insect farming with smart agriculture and waste management can promote sustainability. Further research on consumer psychology, safety risk assessment, and global trade regulations will facilitate broader adoption.

4. Conclusion

Edible insects are nutrient-rich, environmentally sustainable, and economically viable protein alternatives. Continued innovation in farming, processing and regulatory harmonization will determine their successful integration into global food systems. Strategic promotion and policy support are essential to transform entomophagy from a traditional practice into a mainstream dietary trend contributing to global food security.

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