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Potential of Edible Aquatic Insects as Future Food

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Major water bodies are rich in flora and fauna biodiversity, including few orders of aquatic insects, that survive throughout their whole life span (beetles, bugs) or during only specific life stages (the larval Odonata, Ephemeroptera, Trichoptera etc.). Aquatic edible insects have tremendous potential as human food due to high nutritional (high quality protein, micronutrients) as well as economic and environmental benefits. The nutritional quality of aquatic edible insects is equivalent or superior to that of diet derived from other animal sources like birds and mammals. Food security and food safety are the major concerns worldwide. High standards food safety measures ensuring consumer health protection and effective hygiene practices need to be introduced. Global acceptance of edible insects as a major constitute in human diet is the major obstacle.

Keywords
Aquatic Edible Insects, Entomophagy, Nutritional Value, Food Security, Risk and Hazards

Introduction

Of all the existing myriad of the true insect orders, 12 are aquatic or semi-aquatic, and 6 of these orders have insectivorous insects of some or all ages. (Greek 'entoma', meaning 'insects' and 'phagein', meaning 'to eat'). The current statistics reflects the identification of over 2100 edible insect species with over billions of humans engaged in entomophagy, which by 2050 is likely to expand to around 9 billion. The most commonly consumed insect orders include Coleoptera (31%), Lepidoptera (18%), Hymenoptera (14%), Orthoptera (13%), Hemiptera (10%), Blattodea (3%), Odonata (3%) and Diptera (2%) (Klaus *et al.*, 2021). Sustainable food security is presently one of the biggest challenges at global level. Edible aquatic insect species with their high nutritional contents, can play a pivotal role in the above context. Interestingly, it is possible to grow edible spices using the method, such as shallow artificial ponds for attracting or placing flat tiles or grass in ponds for growth and colonization. The concept of entomophagy is attracting population worldwide and has seen an expansion in Western countries. Food safety issues, potential risks and hazards (allergens, heavy metal, pesticide residues, and uric acid composition) have become a concern because of the limited knowledge in area of insects in food production. Despite various advantages of edible aquatic insects, consumer acceptance remains a major barrier to the adoption among the people.

Aquatic Insects as Food

Homo sapiens have a long chain of history and rich customs and cultures of entomophagy. To some ethnic groups, it is not just a traditional practice of the consumption of insects, but is also part of their ethnic culture and indigenous ecological knowledge. In recent years, considering their outstanding value, aquatic insects as potential food source have gained a substantial amount of attention as source of nutrition. The diverse population of aquatic insects (around 76,000 species), living in a wide range of aquatic (and semiaquatic) habitat have a great potential to service humans with nutrition and health benefits (Zhao *et al.*, 2021). Edible aquatic insects contribute about 15% of the total edible insect species (2000). Six of the 12 orders of aquatic insects have suitable species for food and feed *viz.*, Coleoptera (beetles), Odonata (dragonflies/damselflies), Hemiptera (true bugs), Diptera (true flies), Trichoptera (caddisflies) and Ephemeroptera (mayflies). Of which, Coleoptera, Odonata, and Hemiptera are the major population (3/4 of the number of species) (Zhao *et al.*, 2021). The naiad or larva is the main edible stage of aquatic insects. The details of 6 insect orders likely to contain candidate species are as follows-

Coleoptera- Globally 78 species, about 22 species are edible. Mexico leads with 36 foods, followed by China (26) and Japan (15) attributed to their anti-diuretic effect, high fat content (21.6%) and strong antioxidant properties (Sarmahet *et al.*, 2022).

Odonata- Odonates have high rates of existing entomophagy in many parts of the world (at least 15 species engaged) (Klaus *et al.*, 2021). The adult dragonflies can be trapped using the sticky sap or using a candle suspended over a dish of water. Nymphs are rarely preferred.

Hemiptera: Globally, Belostomatids (giant water bugs) are a well-liked delicacy, in particular, *Lethocerus (=Kirkaldyia) indicus*. The studies have recorded consumption of *L. indicus* together with the water scorpion, *Laccotrephesmaculatus* (Nepidae), amongst the indigenous peoples of Manipur, India. These studies document the consumption of *L. indicus* and the water scorpion *Laccotrephes maculatus* (jellyfish family) among the Manipur indigenous people of India Major species consumed are collected during the rainy season (May– July) from the ponds and wetland habitats.

Diptera: Simulids, Tipulids, Chaoborids and Chironomids have high potential as edible aquatic food.

Trichoptera: There are few records of entomophagy in caddisflies to be part of the human diet, because of their accessibility and larval size. In Japan, trichopterans are known for the famous dish Zaza-mushi (Zhao *et al.*, 2021) (larvae are boiled and then sauteed in soya sauce and sugar). The most commonly eaten species are *Stenopsyche griseipennis*, *Parastenopsy chesauteri* and *Cheumatopsy chebrevilineata.*

Ephemeroptera: There are more than 3000 species of mayfly, major ones are lotic. Their phototrophic nature aids in bulk gathering for processing and storage. However, the minor lentic species, suchas *Hexagenia limbata* (Ephemeridae) have the potentialto be raised in culture. Rare species such as *Hexagenia limbata* (Ephemeridae) can be supported in aquaculture. Both the nymphs and adults are eaten

directly or in paste form known as kungu (mayflies (*Caeniskungu*) Mix with mosquitoes, (Williams *et al*,. 2017) make dry desserts), sauce or food.

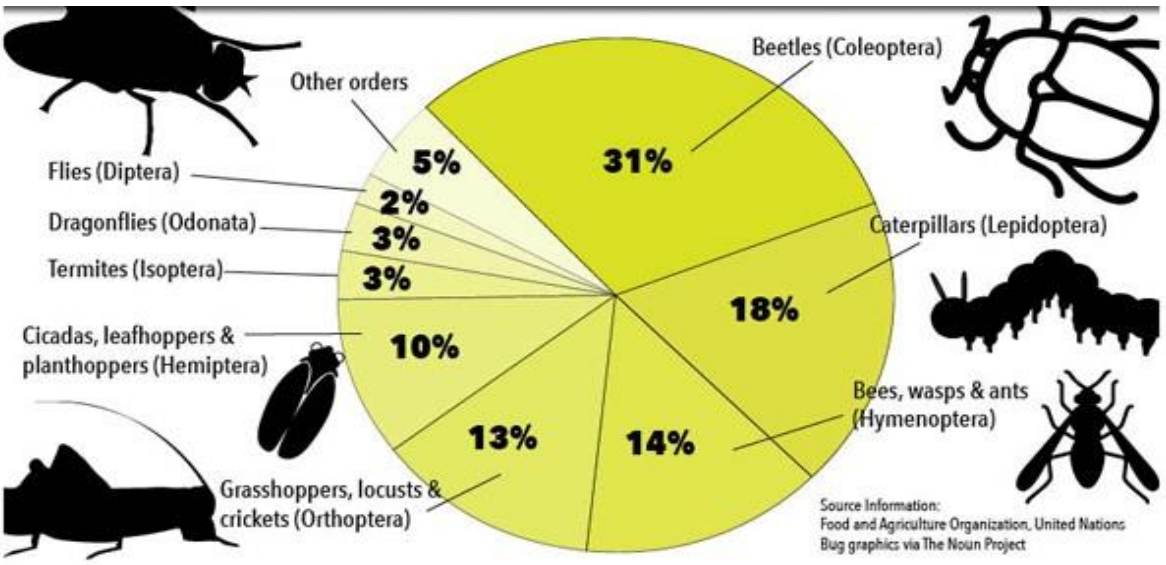

Figure 1: Most commonly eaten insects around the world (FAO, 2023)

Nutritional Aspects

There is very scarce information available in relation to the nutritional aspects of aquatic insects. What is known is that Insects are a highly nutritious source of food, with high protein, fat, vitamin, mineral and fibre content. In general, they are excellent sources of protein (35% to 77%) and is in a similar range to that of pork and beef (40–75 g/100 g dry weight). The crude protein content of dried mayfly nymphs is reported to be 66%. Chironomids contain 56% crude dried protein. Insects are high in mineral content (e.g. iron and zinc), B-vitamins, and essential amino-acids (FAO 2023). The total fat content of insects has been reported to range from 10% to 60%. However, they tend to be low in carbohydrates and protein. A report by the FAO conclude that many edible insects are good sources of minerals such as iron and zinc (FAO 2023). High levels of magnesium in crickets, grasshoppers, crickets and termites contain high concentrations of iron and zinc. Higher level of Copper, magnesium, manganese and zinc levels found in grasshoppers and mealworms. The nutritional profile of edible insects depends on the species and can be highly variable. Even within the same group of insect species, the nutritional value may differ due to diet, metamorphic stage, habitat and environmental conditions. The chitinous exoskeleton of insects serves as rich source of fibre (FAO, 2023).

Constrains and Challenges

Food security and Food safety are linked concepts and any one of them can't be ignored. The increasing population increase the demands of food that can be fulfilled by exploring the novel substitutes. Aquatic edible insects are capable of providing a valuable source of food as they are rich in protein, vitamins and minerals needed for human health and wellbeing. But food safety is also the bigger concern at the same time. A water body is an open environment, which readily accumulate many substances through water flow, soil, etc. and there is a close relationship between aquatic organisms and water. Aquatic insects easily gather various pollutants, including heavymetals, pathogens, pesticides, ant-nutritional compounds etc. These contaminants may enter the human body through the food chain. Over 33 metallic elements of aquatic edible insects have been detected, and heavy metals, such as Hg, Pb, Cd, and Cr, have attracted serious concern. Aquatic insects are important vectors (e.g., malaria) of environmental pathogens. All these facts have attracted attention as a food safety issue.

Conclusion

Edible insects appear to offer an alternative and sustainable means of meeting the increasing nutritional demands of a globally expanding population. However, several challenges need to be taken in employing the potential applications of edible insects to enhance food security. The environmental impacts and sustainability of rearing, harvesting and producing insects need to be examined.

Author contributions

All authors listed have made a substantial,

direct, and intellectual contribution to the work, and approved it for publication.

Conflict of interest

The authors declare that the manuscript was formulated in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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