Background Information on Edible Insects & Human Health
Written By: Valerie Stull, MPH

Edible insects have been consumed throughout human history[1,2] across Asia, the Americas, Africa,[3] and Australia.[4] Even native populations of North America, especially in the west were known to consume insects and expend significant effort to harvest them.[3] Insects served as an important component of the diet for many populations, traditionally making up more than 50% of animal protein intake in parts of central Africa[5] and containing macronutrient values similar to that of wild meat, shellfish, nuts, pulses, and some vegetables.[6] Entomophagy—the practice of eating insects—continues today, as nearly 2 billion people[7] from 3,000 ethnic groups in 130 countries[8] regularly consume insects, selecting from more than 1900 known edible species.[9] These people are spread across 80% of the world's populations.[10] In Africa alone, at least 500 species are consumed in 40 different nations.[11] Even within the last century, some groups have relied heavily on insects, such as residents of the Kwango District in the Democratic Republic of Congo who garner nearly a third of their animal protein intake from insects.[12,13] Today, there are more than 24 food companies selling insect-based food products in North America alone, and the edible insect industry is growing rapidly in Europe as well. In 2015, the European Food Safety Authority took preliminary steps to assess the food safety of edible insects, as they are widely available in Europe thanks to trade with Asian producers and the emergence of new businesses in Europe. The Food and Agriculture Organization of the United Nations (FAO) has deemed many edible insects safe to eat when properly prepared.[7]

Edible insects are nutritionally dense, offering a good source of bioavailable animal protein for those that partake.[14] Many edible species contain high crude protein levels,[15,16] with between 40 and 75% protein by dry weight on average,[17] higher than that of ground beef.[18] Insect protein quality is also superior, as the amino acid content of most edible insects is comparable to WHO recommendations for amino acids required for human nutrition,[19] and insects commonly contain and all essential amino acids.[20] In general, insects are rich in fatty acids,[15] with numerous species supplying ample poly-unsaturated fatty acids (including essential linoleic and linolenic acids).[21] The exoskeleton of insects contains chitin, making insects a source of dietary fiber, with chitin accounting for about 10% of whole dried insects.[15] Chitin, a modified polysaccharide, is abundant in nature and has been evaluated for it health-promoting properties. For examples, chitin-glucan derived from *Aspergillus niger* mycelium reduced oxidized low-density lipoprotein in adults, a risk factor for atherosclerosis, when consumed at a rate of 4.5g/day.[22] Insects are also typically good sources of minerals including potassium, calcium, copper, magnesium,[17] manganese, phosphorous, and selenium,[23] [24] as well as the ever important iron and zinc,[25] which are crucial for growth. Some insect types are particularly high in B vitamins,[17] such as biotin, riboflavin, pantothenic acid, and folate.[23] Caterpillars, for example, contain as much as 300 times more than daily requirement for adults of iron, along with ample zinc.[26] As such, insect consumption has been proposed as one way to decrease iron and zinc deficiency in developing countries[25] and reduce malnutrition globally. It should be noted, however, that the nutritional value of insects can vary greatly by species, lifestage,[27] and feed source(s).[28]

From an environmental perspective, insects are a plentiful natural resource, comprising ~1 million of the 1.4 million species on the planet.[7] The environmental impact of edible insects is significantly lower than traditional livestock,[7,20,29] as they need less land, water, and feed to survive and thrive,[7] and emit fewer greenhouse gases (GHGs).[29] Their high feed-conversion ratio,[20] ectothermic thermoregulation, and large edible body mass percentage[30] contribute to overall sustainability and desirability. Production of 1 kilogram (kg) of live animal mass requires about 2.5kg of feed of poultry, 5kg for swine, and 10kg for beef,[31] whereas crickets demand as little as 1.7 kg feed per kg of mass gained. [20] Excluding scarab beetles, cockroaches, and termites, edible insects do not produce methane (CH4),[32] an especially powerful GHG with a significantly higher global warming potential (GWP) than carbon dioxide (CO2).[33] The total GHG emissions of several common edible insects (crickets, mealworms, and locusts) are lower by a factor of about 100 than pigs or beef cattle.[29]

Despite the numerous perks and overall global popularity of edible insects, a more research is needed to explore the health impact of entomophagy on consumers, including their ability to curb protein deficiencies or undernutrition, influence the microbiota of humans, and address micronutrient deficiencies. Research exploring and addressing challenges with current collection, processing, and consumption methods, as well as new innovations that harness the relatively untapped potential of edible insects are needed.

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