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Research Article

Benefits and Risks of Consuming Edible Insects

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***Abstract*:** Insect eating has been reported for a long time, and they are consumed in raw and processed forms by several cultures around the world, especially in developing countries, where they are typically regarded as a delicacy in addition to providing nutrients, farming, processing, and consumption of edible insects have recently sparked a lot of research interest, mostly in an effort to mitigate food insecurity and improve nutrition in many developing nations. Edible insects have been demonstrated to improve the nutritional content of foods by providing micro- and macronutrient levels that are comparable to, if not higher than, those found in animal-derived foods. Even with all of these advantages, promoting edible insect cultivation and consumption in developed and developing countries faces a number of hurdles. In many Western countries, however, consumer acceptance of insects as a food source remains a major challenge. The problem of food safety is at the top of the list of these challenges, with many western consumers concerned about the microbiological and chemical health risks that edible insects or edible insect-derived foods may provide. According to the available research, there is a clear need to strike a balance between the nutritional benefits of edible insects and its food safety concerns.

***Keywords*:** Edible insects, Entomophagy, Food safety, Food security

Introduction

Insects found in agricultural, aquatic, and forest ecosystems are an important world biomass resource (New, 2009). The practice of eating insects as an alternative source of food also known as entomophagy (Pager, 1973), has long been a feature of human history (Meyer-Rochow, 2010; Evans, 2015) and prehistory (Backwell & Errico, 2001; Pager, 1976) and are still part of the human diet in many parts of the world. Insect ingestion is thought to be a part of the traditional diets of approximately two billion people around the world (van Huis et al., 2013). People in the United States, South Africa, and Spain have consumed ants, beetle larvae, ticks, termites, lice, and mites since prehistoric times, according to studies (Lesnik, 2014). Although, as compared to traditional meat consumption or the vegetarian movement, entomophagy is not relatively a new concept, it has been present for over a century. Many ethnic groups in Asia, Africa, South America, and Mexico consume edible insects as street food, snacks, or as part of a meal (Zhao, 2007). Eating edible insects dates back over 7000 years (Ramos-Elorduy, 2009). More than 2300 edible insect species from 18 orders have already been reported, with

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5 orders having at least 100 records. These insects can be found in both terrestrial and aquatic habitats (Jongema, 2017). Although certain species are farmed on a massive scale, the majority of them are being gathered from nature.

Insects that are commonly consumed includes Coleoptera (beetles) (31 %), Hemiptera (cicadas, planthoppers, leafhoppers, true bugs, and scale insects) (10 %), Hymenoptera (ants, wasps and bees,) (14 percent), Diptera (flies) (2%), Lepidoptera (caterpillars) (18 %), Orthoptera (crickets, grasshoppers, and locusts) (13 %), Odonata (dragonflies) (3%), and Isoptera (termites) (3 %) (Jongema 2017). Furthermore, eating insects are beneficial to one's health and nutrition. These insects have a high nutritional value and can be used as a supplementary component in bread or porridge (Vantomme, 2012). Aside from that, eating insects feed human bodies with proteins, calcium, and vitamins (Rumpold, 2015). For example, studies have discovered that most of these edible insects have a higher protein content than meat or fish (Kouřimská & Adámková, 2016). In addition, Aborigine cultures have traditionally employed edible insects as a medical therapy. In China, for example, insects such as bees are used as nutritional elements in a variety of tonics and healthful dishes. Furthermore, China's State Health ministry and State Food and Drug Administration approved the sale of more than 30 ant-containing health items since 1996 (Shen, Li & Ren 2006).

The nutritional aspect of edible insects

In general, insects have apparent nutritional advantages. Their nutritional profiles are remarkably comparable to that of traditional animal meat (Raubenheimer & Rothman 2013) not only for humans, but also for livestock, they have huge potential as a source of active substances and nutrients . Edible insects are a good source of important nutrients that can help humans achieve their nutritional needs. In the recent decade, published scientific research on their nutritional content has increased, and the evidence suggests that edible insects are a rich source of nutrients and can be used to combat malnutrition, with some insect species contributing significantly to the Recommended Dietary Allowance (RDA) (Weru et al., 2021). They are found to be a high-protein, high-fat, high-vitamin, mineral, and high-fiber source of food and their nutritional profile varies greatly depending on the species metamorphic stage, diet, habitat, and environmental circumstances can all affect the nutritional value of insects, even within the same species (Lange, & Nakamura, 2021).

The nutritional profiles of a range of edible insect species have recently improved, and the frequency of entomophagy-related publications published annually has climbed from <10 pre-2012 to 114 in 2020. The general agreement is that edible insects have a good nutritional content and could be a viable substitute to meat and fish in the diet (Rumpold, and Schluter, 2013; van Huis et al., 2013; Hlongwane et al., 2020). However, it is commonly acknowledged that edible insect nutritional profiles differ significantly between species. Within

Coleoptera, for example, Rumpold and Schluter (Rumpold and Schlüter, et al., 2013) discovered a protein content ranging from 8.85–71.1 % on a dry matter basis. Similarly, R. phoenicis, M. bellicosus and Z. variegatus, have been found to exhibit significant variances in protein, lipid, and ash, a mineral content indicator (Omotoso and Adedire, 2007), and also amino acid profiles (Womeni et al., 2009; Awobusuyi, 2021). The amino acid needs for adults given by the World Health Organization are shown alongside the essential and non-essential amino acid composition of widely eaten insect species (WHO, 2007). However, methionine, cysteine, and tryptophan are all missing or present in extremely little amounts in some insects. If these insects make up the majority of a meal, the diet must be balanced. Insects, with the exception of these species, generally satisfy the WHO's amino acid recommendations. By ingesting a reasonable variety of items, the majority of them can offer enough amounts of essential amino acids. On a dry weight basis, the fat content of insects in embryonic stages ranges from 8 to 70%. Various sources of meat, along with all groups of insects, have identical fatty acid contents (Bukkens, 1997). Lepidopteran and Heteropteran larvae have a higher fat content than other edible insects. When compared to other stages of insects, larvae seem to be the best source of fatty acids. Adults are generally slender, with a fat level of less than 20%. Triacylglycerol is the most common type of fat found in insects (Arrese & Soulages 2010). More than 80% of all fats are made up of monounsaturated fatty acids (MUFAs) and saturated fatty acids (SFAs). Palmitic acid and stearic acid make up the majority of SFAs in insects at various times.Moreover, insects are also rich in vitamins and minerals, yet feeding has been shown to alter their contents in some studies. Biochemical substances like vitamins A, B1–12, C, D, E, and K, that are required for normal growth and health (Kouimská & Adámková 2016), could be provided by them. Caterpillars, for example, are particularly high in B1, B2, and B6 (Rumpold & Schluter 2013). Vitamins A and D are abundant in bee brood (pupae) (Finke 2005). Rhynchophorus ferrugineus, the red palm weevil, is a rich source of vitamin E. (Bukkens & Paoletti 2005). Edible insects include a wide range of micronutrients, including iron, manganese, magnesium, potassium phosphorus, selenium, sodium, and zinc (Rumpold & Schluter 2013).

Many insects have chitin in their exoskeletons, which supplies a large amount of fibre. Chitin content varies by insect species as well as developmental stage (Finke, 2009), accounting for about 10% of dried weight (van Huis, 2013; Belluco et al., 2013). Purified chitin contains about 90% dietary fibre (Maezaki et al., 1993), which is easily digestible by humans (Paoletti et al., 2007). Chitin and its deacylated derivative, chitosan, may help with cardiovascular and gastrointestinal health, innate and adaptive immunological responses, cholesterol lowering, and wound healing (Tripathi and Singh, 2008; Lee et al., 2008; Prosky, 2000). Furthur, edible insects are also found to be a great source of calories, with caloric contributions ranging from 290 to over 750 kcal/100 g. (Ramos-Elorduy et al. 1997).

Food security

Food insecurity is likely to rise even more globally, continuing a trend that began in 2014, especially throughout the Caribbean and Latin America, and adding to already high levels in Africa and South Asia (FAO 2020). Moreover by 2050, the world's population is expected to increase by a quarter (UN, 2021), In many regions of the world, per capita meat demand is increasing in tandem with population growth. This is especially noticeable in high-growth regions rather than low-income ones, with the link between prosperity and meat intake is well-documented (Asian, 2012). In low-income countries, the combination of expanding populations and wealth is exacerbating food insecurity challenges (Msangi and Rosegrant, 2012); discovering alternative, much better sustainable protein sources is critical for combating rising under-nutrition and establishing long-term food security (Anankware, et al., 2021).

Entomophagy, or the human consumption of insects, has significant potential in combating these concerns and is extensively practised around the world, particularly among traditional groups (Dickie, 2019). Despite popular belief, communities practising entomophagy see insects as a delicacy instead of a "hardship" food in times of famine (Halloran and Vantomme, 2013); locusts, for example, are regarded to have been popular among the ancient Near East's social elite (Lanfranchi, 2015). With insect species being detected in human coprolites and several researchers even claiming a similarity between insectivory in human and nonhuman primates, it is becoming increasingly obvious that entomophagy had played a vital role in delivering sustenance throughout hominin evolution (Tommaseo-Ponzetta, 2005). There is a large diversity of edible insect species (Anankware et al., 2015; van Huis et al., 2003), with over 2,000 formally listed species (Jongema, 2017). The popularity of entomophagy, as well as the species consumed, varies greatly around the globe. Edible insect farming, consumption and processing, have recently sparked a lot of research interest, mostly in an effort to alleviate food insecurity and improve nutrition in many developing nations. Edible insects have been demonstrated to improve the nutritional content of foods by providing micro- and macronutrient levels that are comparable to, if not higher than, those found in animal-derived foods. They can be utilised to directly target the first three Sustainable Development Goals of the United Nations in this way (zero hunger, no poverty, well-being and good health). Edible insect production also aids in the mitigation of climate change's negative consequences and the improvement of biodiversity, both of which contribute to food security (Imathiu, 2019).

Risks related to consumption of edible insects

Problems can arise even while consuming edible insect species and handling them. Consumption of insects during unsuitable stages of development, improper culinary preparation, handling without safety equipment, or gathering of insects from unsuitable places can all cause negative reactions.

Allergies

A food allergy (Johansson et al., 2004) is an immunological reaction to food that is triggered by compounds known as allergens. Food allergies can cause significant sickness and even death. Food allergy is a significant public health concern whose care along the food value chain remains a serious challenge for the food industry and medical professionals across the world. Sensitive people might be allergic to a wide range of foods, and any protein-containing food can potentially produce an allergic reaction in sensitive people (Boye et al., 2012).

Proteins are the most abundant component of edible insects. Some insects and insect-derived foods may be viable allergen sources. Some types of edible insect proteins such as arginine kinase are considered allergens, according to Murefu and colleague (Murefu et al., 2019). Because insects are linked to crustaceans, the possibility of them causing food allergies has been hypothesized. According to a study conducted in Belgium, skin prick tests produced using grilled A. domesticus and T. molitor insect samples sensitised 19 % of people, implying that a broad population could be at risk of having allergic reactions if certain edible insects species are consumed (Francis et al., 2019). Likewisw, Okezie and colleagues (2010) documented the case of a 36-year-old woman who experienced two bouts of anaphylactic shock after eating mopane caterpillars (The patient had eaten this mopane worm before and had no adverse responses). There was no skin prick test in this case.

Pener reviewed food allergy to insects, including grasshoppers and locusts, in 2014, and found seven cases of severe allergic reactions after eating fried crickets and grasshoppers during a two year duration in a Thai hospital emergency room. In addition, between 1980 and 2007, the Chinese literature reported 27 cases of anaphylactic shock induced by grasshopper intake and 27 cases caused by locust consumption (Pener, 2014). The majority of people who eat edible insects have a little to no chance of developing allergic reactions, specifically if they have never had an allergy before. However, because frequent exposure to an allergen might cause sensitivity, insects should be consumed with caution when first introduced into the diet. To assess the hazards of edible insect dietary allergy, more research is needed.

Pathogenic microorganisms in edible insects

Recent research on the microbial potential hazards associated with edible insects has revealed the potential existence of harmful bacteria in these diets (Garofalo et al., 2017). Many potentially human harmful bacterial taxa, such as Vibrio, Staphylococcus, Streptococcus, Clostridium, and Bacillus, were found in a study assessing the variety of microbiota found in edible insects prepared and sold in Thailand (Osimani et al., 2017).

Parasites in insects

The prevalence of parasites in insects is widely documented in a study of food borne pathogenic intestinal flukes in Southeast Asia, which detailed the isolation of 6 distinct species from insects; there is a long, widespread tradition of insect ingestion in this region. Food - borne illnesses caused by transmission of parasites (trematodes) belonging to the families Lecithodendridae and Plagiorchidae has been hypothesised based on evidence from human autopsy and insect analyses (Chai et al., 2009). Another parasitic zoonotic agent that could infect people through insect eating is Dicrocoelium dendriticum. The infection is caused by eating ants that carry metacercariae, however pseudo-infections (the presence of D. dendriticum eggs in the faeces but no adult worms) are caused by eating infected animal liver. In the urban area of Kyrgyzstan, the frequency in children (2 to 15 years old) was 8.0 %, despite the diagnostic test failing to separate between infection and pseudo-infection (Jeandron et al., 2011).

The scientific literature contains only rare evidence of potentially hazardous parasites in edible insects. A well-managed closed farm setting, on the other hand, would be clean and free of all the hosts required for parasite life cycles to be completed. In every case, adequate management before eating, relying on freezing, boiling and cooking, could limit dangers, especially with picked rather than farmed insects (Belluco et al., 2015).

Fungi

Insects may also carry fungus and yeasts that can be harmful to both animals and humans. Fresh, freeze-dried, and frozen insects (L. migratoria and T. molitor) all included significant levels of yeasts and fungi (FASFC, 2014). A study from Botswana emphasised the significance of adequate handling, processing, drying, and storage when unacceptable concentrations of aflatoxins were discovered in some commercial batches of mopane worms (Gonimbrasia belina: Saturniidae) (Schabel, 2010). Some fungi (Aspergillus sp., Penicillium sp.) were isolated from the same species and dried under laboratory conditions, among which are also mycotoxigenic species (Simpanya et al., 2000). Fungi related with insects produced for feed and food, or introduced during processing, storage, and farming, could provide a concern in general.

Heavy metal contamination in edible insects

For five distinct varieties of edible arthropods, cadmium and lead concentrations varied from 0.02–0.07 mg/kg and 0.03–0.10 mg/kg dry weight, respectively (Banjo et al., 2010). Dried grasshoppers also known as Chapulines were suspected of causing high blood lead levels in residents of a California neighbourhood (Handley et al., 2007). The latter researchers looked at the causes of a lead poisoning outbreak in Monterey County, California. Between 2001 and 2003, they wanted to look into risk factors for high blood lead concentrations (> 10 g/dL) in pregnant women and children in three country health department clinics. One cause of lead poisoning was thought to be homemade dried grasshoppers (chapulines) being sent Oaxaca, Mexico. Significant quantities of lead were found in these chapulines from the total of ten chapuline samples collected in Zimatlan, Oaxaca, there was a wide range of lead content, ranging from undetectable to 2500 mg/kg (Handley et al., 2007).

Blue bottle (Calliphora vomitoria), House fly (M. domestica), black soldier fly (H. illucens), and blow fly (Chrysomya sp.) cultivated using a wide range of substrates and methods of production at various geographic locations were evaluated for metals in an investigation of the chemical safety of farmed insects (Charlton et al., 2015). Cadmium was found at amounts in some edible insect samples that exceeded the highest residual limit for entire animal feed, but this was not the issue for the other metals tested. In a field research using phytophagous larvae of the Noctuid moth (Spodoptera litura), no cadmium or lead bioaccumulation was identified, despite significant quantities of these metals in larval faeces (Zhuang et al., 2009). Because metal buildup in insects is influenced by a variety of parameters such as age, physiology, sex, and heredity. In addition, according to Idowu and colleague in 2014, some termite species have a lesser tendency to accumulate heavy metals (Idowu et al. 2014). Further, Banjo in 2010 detected significant amounts of nickel, cadmium, lead, zinc, and sodium in the larvae of Anapleptes trifasciata (beetle) and Rhynchophorus phoenicis (beetle). Diener and his colleague in 2015 found that cadmium accumulation ranged between 2.32 and 2.94%, lead stayed below its baseline concentration in feed, and zinc reduced from 0.97 to 0.39%. When the black soldier fly H. illucens was fed chicken feed contaminated with cadmium, lead, and zinc, the black soldier fly H. illucens level of cadmium, lead, and zinc was spiked (Diener et al. 2015). Finally, the major route of contamination for edible insects appears to be heavy metal transfer from substrates (e.g. plants, organic matter). The amount of metal accumulated is determined on the insect species, growth stage, and the metal in question.

Antinutrients

Antinutrients, also known as antinutritional factors, are generally occurring compounds in meals that hinder the intake, absorption, digestion, and use of nutrients (including macro- and micronutrients) (Akande et al., 2004). These chemicals, which are more frequent and have larger concentrations in plant-based foods than that in animal-based foods, may have other negative health impacts on consumers depending on the kind and concentration in foods. Antinutrients of various sorts have been identified and quantified in a number of edible insect species. Antinutrients (hydrocyanide, tannin, oxalate, and phytate) were discovered and measured in four species of insects in Nigeria (Ekop et al. 2010). Long-horned beetles, grasshoppers, meal bugs, and termites are among the insect species shown to contain phytates and tannins (Musundire et al., 2016). Saponins and alkaloids are two more antinutrients that have been found and studied in edible insects (Musundire et al., 2014). In order to create strategies of either eliminating antinutrients before consumption, avoiding eating of the implicated insect kinds, or seeking an alternate insect type for consumption, it is necessary to know what antinutrients are found in particular insect species.

Conclusion

Due to global growing population, rising demand for and cost of animal protein, food shortages in some parts of the world, and increasing environmental challenges, the utilisation of edible insects as a source of food for humans has been a topic of global concern. One of the most pressing global concerns is ensuring environmentally sustainable food security. The research suggests edible insects can potentially play a key role in resolving food and nutrition insecurity, and this should be emphasized. Scientific evidence reveals that the nutritional quality of edible insects is comparable to, and sometimes even exceeds, that of animal-based diets. This, along with the fact that edible insects grow quicker, convert more food, and require fewer resources to nurture than cattle, should make them an even more appealing quality food source, particularly for the rural poor in developing countries. Edible insects might generally be recognised as safe (GRAS) foods in nations or communities where entomophagy is practised, but that is not the situation in most developed nations, where most consumers are cautious of their safety and consequently hesitant to incorporate them in their diets. There is a scarcity of scientific information on edible insect food safety issues. More research is needed to better understand the dangers associated with their intake in order to protect consumer health. As a result, entomophagy should be promoted and supported worldwide, but there must be a balance maintained between consumer worries about food safety as well as the nutritional and health advantages of this food type. The development and implementation of edible insect legislation rules in both emerging and developed nations should be promoted, as this can help facilitate commerce in this commodity in the long run, in addition to assuring safety. Future research towards up-scaling edible insect production and marketing should be prioritised.

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