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MINI-REVIEW

Prospects of entomophagy

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Abstract
The constant rise in the human population has led to food insecurity and malnourishment issues across the globe. Acceptance and popularization of entomophagy in society can help to meet the increasing demand for food supply. The high nutritive profile of edible insects makes them an excellent supplement in the diet. Consumption of edible insects as food and use in medicine is common among various tribes of the world. However, a major fraction of people is reluctant to accept insects as food. The harvesting of insects when done properly considering all the associated factors, can act as a source of livelihood and the profit margin of insect farming can exceed that of grain. There is a need for proper documentation of the edible species, preparation procedure, and their therapeutic properties along with multi-disciplinary research for sustainable development and commercialization.

Keywords Edible insects · Entomotherapy · Food · Insect farming · Sustainable

Introduction

Reduction in crop productivity and scarcity of food resources has caused food insecurity issues in many regions across the globe (Gahukar 2011). Among various ethnic groups across the world, the presence of a vast number of native insects has played a role as an alternative food source to deal with the issue of food insecurity. Entomophagy or consumption of edible insects can act as a sustainable resource due to the provision of mass collection within a short duration, high intrinsic growth rate, and need of less rearing space. Due to the positive impact of insect consumption on human health as well as livelihood, Food and Agriculture Organization of United Nations labeled insects as an alternative food source to combat food insecurity issues (FAO 2010a, b). This review attempts to shed light on the prospects of using insect as food supplements to meet the increasing consumer demand and taking up this promising business of insect culture as a source of income.

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Insects in human culture

Practiced by humans since ancient times, entomophagy dates before the practice of hunting animals for food (Ramos-Elorduy 2009; Sponheimer et al. 2005), and in current times reflects on the social implications, addressing issues of malnutrition and maintenance of healthy nutrition (Batat and Peter 2020). The ethnic groups of Asia, America, and Australia consume around 1500–2000 species of insects (MacEvilly 2000). In Africa, about 470 insect species have been listed as edible and most of them are caterpillars followed by beetles, termites, and grasshoppers (Van Huis 2020). An important aspect of entomophagy is proper identification of the edible insects scientifically, assessment of the nutrition level (Ademolu et al. 2004; Fagbuaro et al. 2006), and maintenance of record of the methods of preparation for consumption (Yen 2009). Also, various tribes in different parts of the world have been practicing entomophagy as a part of medicine (Chakravorty et al. 2011; Srivastava et al. 2009).

Insects have always occupied an important position in folk medicine. With modernization, tribal communities are slowly giving up the practice of using insects in remedies, so there is an urgent need for documentation of the ancient traditions and knowledge about insects with therapeutic properties (Meyer-Rochow and Chakravorty 2013). Certain tribes of Northeast India use several insects to treat

ailments such as cough and cold, stomach disorders, skin allergies, malaria, hypertension, and foot and mouth disease in cattle (Chakraborty et al. 2011). Termites have been used by many South Indian communities to cure asthma and enhance lactation in women (Wilsanand 2005). There are even claims regarding antibacterial and anticancer properties of insect secretions (Srivastava et al. 2009). The therapeutic potential of insects as an analgesic, diuretic, antibacterial, anaesthetic, and antirheumatic has also been proven by scientific studies (Costa-Neto 2005). Entomotherapy and entomophagy demand the need of procuring a significant amount of insects. However, to prevent over-exploitation from nature, there is a need for legislation to regulate the multi-dimensional nature of entomophagy. Countries like Thailand, Switzerland, Canada, and Kenya have formulated laws and policies aimed at insects for human consumption (Halloran et al. 2015). Insect rearing for consumption is associated with certain moral obligations and ethics too. Some ethicists believe that insects should be allotted moral rights as they are living entities (Pali-Schöll et al. 2019) while others question sentience in insects (Feinberg and Mallat 2016).

Nutritive aspects of entomophagy

Insects have been recognized worldwide as an excellent food source owing to its high nutritive value, being known for their high energy content and protein reserve (Gahukar 2011). Compared to plants, insects have higher level of protein. For example- The raw protein content of larvae of Ephemeroptera, Odonata, Homoptera, Hemiptera, Coleoptera, Lepidoptera, and Hymenoptera are 66.26%, 40–65%, 40–57%, 42–73%, 23–66%, 20–70% and 15–76% respectively (Chen and Feng 1999; He et al. 1999; Lu et al. 1992; Chen et al. 2009). Insects also provide carbohydrate and fat (Gahukar 2011). It has also been found that edible insects have high-fat content in larval and pupal stages with considerably low fat in adult stages. In addition, insects contain micronutrients such as copper, magnesium, iron, biotin, riboflavin (Rumpold and Schluter 2013), calcium, iron, and zinc (Chen and Feng 1999). The consumption of insects is subjected to their abundance and availability, which makes insects of certain orders such as Lepidoptera, Coleoptera, Hymenoptera, and Orthoptera an excellent choice in the diet (Defoliart 1995; Raubenheimer and Rothman 2013). They have an appetizing taste and can be consumed at various stages of the life cycle, depending on the type of species, they can be served raw or toasted (Ramos-Elorduy 2009). Edible insects consumed by Australian Aboriginal people have low-fat content and high in polyunsaturated fatty acids content (Naughton et al. 1986).

Farming of insects and associated factors

The sustainable production of edible insects to meet the food demands of a country, while keeping in mind the ecological balance is a major challenge (Yen 2009). An important thing to remember while dealing with entomophagy is that not all insects are edible and therefore, proper identification and knowledge are mandatory. Certain insects have toxins (DeFoliart 1992), while some might cause allergic reactions to people (Auerswald and Lopata 2005). Harvesting of insects should be done keeping in mind all the associated factors and risks. A potential risk of consumption of harvested insects is the pesticide residue in them. Due to this many farmers prefer not to opt for insecticides as profit from insect production exceeds that of grain (Abate et al. 2000; Pemberton 1994). In insect farming for commercial purposes, maximizing the benefits with minimum investment should always be a goal. To do so, farmers must give special attention to the feed as it affects the insect growth rate. If an insect is edible and capable of converting non-nutritive feed and by-products into human food (Lalander et al. 2015; Vassileios and Langton 2017), then it increases the profit margin considerably. Also, the geographic location and climatic conditions of the insect rearing site have a determining factor in the rearing process (Berggren et al. 2009). The risk of accidental release of insects into the environment from the rearing site and conversion of commercial insects into invasive species should not be overlooked (Kenis and Branco 2010). Instead, precautionary principles such as risk assessment and proper legislation should be followed (Manchester and Bullock 2000).

Insect farming, processing, and commercialization are common in many regions of Southeast Asia, Africa, and Latin America (Gahukar 2016). China has a long history of insect consumption which high acceptance level (Feng et al. 2017) that dates back more than 3000 years (Chou 1980). Western countries have however not utilized the edible insect industry to its full extent (Osimani et al. 2017). Entomophagy needs to be understood properly and practiced to fulfil the growing food demand and meet the need for animal protein in the diet. It has its advantages such as the need for comparatively less space and less time to grow and multiply. Mass rearing of insects can also be done in low income areas, thus providing livelihood. In instances of natural disasters too, insects can be utilized as a source of emergency food (Gahukar 2011).

Insect rearing as a business opportunity

To meet the daily protein requirement in diet, people take supplements and insects can act as an excellent protein supplement in diet. However, not all people prefer to consume insects as a whole or as a delicacy. Instead, they might prefer in other processed forms. Understanding and addressing the

attitude of consumers towards various insects as food in different forms is the key to a successful business in the field. Studies conducted with insects introduced in the form of protein powder to consumers have recorded a positive response. However, there are concerns related to the potential toxicity in insects and associated microbes (Barton et al. 2020). The microbiological profile of the insects varies as per their environment and the consumer risks can be minimized by scientifically evaluating the process behind traditions (Grabowski 2020). The benefits of edible insects can be capitalized by generation of knowledge-sharing networks, advocating policies and conducting inter-disciplinary research (Stull and Patz 2020). Harvesting of insect species that can benefit in more than one way, can lead to enhanced income. For instance, silkworms are considered as an insect of multiple benefits as the matured larvae are known for producing silk fibres while pupae serves act as an excellent food source (Zhou and Han 2006). Another important insect falling in this category of multiple benefits is the honeybee, which produces highly nutritive honey and bee wax. Some communities do not even remove bee larvae while procuring honey from the combs and this result in enhanced protein levels in the honey (Murray et al. 2001).

Harvesting of insects in Africa contributes to their food security (Van Huis 2020) and African food markets are known to sell edible insects and their products (Das 2020). A study conducted in marginal areas of Lake Victoria, to popularize the consumption of termites and lake flies as processed foods, showed that processed forms were more readily accepted by consumers (Ayieko et al. 2010). Thus, converting edible insects into processed products can help in commercialization. In many Western countries, psychological barriers and cultural reasons cause people to reject the idea of insects as a source of animal protein, which can be dealt with some extent with positive sensory experience (Orkusz et al. 2020). The phobia of entomophagy that exists in many western nations ((DeFoliart 1999) has made its way across the world as an impact of globalisation and adapting to western values and cultures (Illgner and Nel 2000). Tradition of entomophagy among the Aboriginal people faced a drastic decline upon European settlement due to the replacement of traditional knowledge by the adoption of new diet plans (Yen 2009). However, the food insecurity issues in Western countries have gradually brought edible insects industry into the light to meet the rising demands (Yen 2009). The food insecurity issues in Western countries have gradually brought edible insects industry into the light to meet the rising demands.

Conclusion

Incorporate entomophagy as a normal practice in the diet, and change the general attitude of humans towards an insect is quite a challenge. So there is a need for spreading awareness among people regarding the benefits of consumption of insects as food and encourage entrepreneurs to take up the insect rearing business (Nonaka 2005). The edible insect industry will flourish only when there is a hike in consumer demand for insects as food supplements and incorporation of innovative ideas and technologies in insect rearing for enhanced production. Thus, new strategies for the effective creation of edible insects through research are constantly needed and, at the same time, their consumption should be encouraged through discussions about their high nutritional value.

Compliance with ethical standards

Conflict of interest None to declare.

Ethics approval Not applicable.

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