



Human Journals

Short Communication

May 2022 Vol.:14, Issue:4

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Possibility of Insect Feeding



Journal of Current Pharma Research
(An Official Publication of Human Journals)
An International Peer Reviewed Journal For Pharmacy, Medical & Biological Science
DOI: 10.25166 CODEN: JCPRD6 NLM ID: 101744065



ISSN: Print: 2230-7834
Online: 2230-7842
SJIF Impact Factor: 6.913

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Submitted: 22 April 2022
Accepted: 27 April 2022
Published: 30 May 2022

Keywords: Entomophagy, Food Shortages, Protein Source

ABSTRACT

Entomophagy is the act of people eating insects as a direct food source, or eating foods containing insects. Insects have long been considered a traditional food source in Asian countries including Japan. More recently people without conventional insect-eating habits have been exposed to insects as a food source, largely due to the considerable protein content in insects which makes it possible to envision it as a solution to future global food shortages. The short cultivation time of insects is an added advantage of using them as a food source. There are, however, uncertainties regarding their use and this article summarizes the advantages and disadvantages of insects as food and describes the consensus of opinions on insects as a source of food.



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INTRODUCTION

Entomophagy is the act of people eating insects as food, or eating food that contains insects¹. Insect-based foods and those containing a small number of insects have been consumed for a long time, and are common traditional foods mainly in the Shinshu region of the Nagano Prefecture in Japan and other Asian countries². A common practice in Japan in the past was to use insects such as Tsukudani (food boiled down in soy sauce), which was served as a side dish. Tsukudani can be preserved, providing a secure source of nutrients for a long time, including over the winter months when access to food is difficult due to heavy snowfall². In recent years, Tsukudani has been processed and sold as a souvenir of traditional food from the area, making it appealing and accessible to tourists. Insects are often sold as light meals and souvenirs or found on soft ice cream and in Manju (a type of sweet bun) at souvenir shops and roadside stations in specific areas. People who have never been exposed now have the opportunity to eat insects and explore new foods containing insects throughout Japan. Insects as a food source are much more accessible in Japan, found alongside sweets and dried fish. The prevalence of insect consumption is a conscious effort to prepare for future global food shortages. This is partly because insects are high in protein and require little effort in their cultivation¹. However, there are some uncertainties about the edible properties of insects. This article summarizes the advantages and disadvantages of entomophagy and describes the public opinion on it.

History of entomophagy

Insect-eating is part of the traditional food culture of Africa, Australia, South America, and Asian countries such as Thailand and China (Tables 1, 2). More than 1,900 types of insects are eaten worldwide³. In Japan, historical records indicate locusts were roasted and eaten by children of farmers during the Edo period (around 1800)⁴. Historically in Japan, insects as a food source have been considered emergency food, only used in scarcity due to war, hunger, or poverty. Until the Taisho era (around 1900), there were areas where insects were generally eaten, and in Nagano Prefecture and elsewhere, bee larva and locusts (rice grasshopper) boiled in soy sauce and Kanroni (food stewed in soy sauce and sugar) existed as local foods. These are still sold at souvenir shops today². Insects have also been used as materials for traditional Chinese medicine, such as Tochukaso (vegetable wasp and plant worm). In Japan today, the appearance of insects creates a negative connotation of them as a food source, and as a result, insects are generally not eaten frequently⁴. Some people avoid eating them too

because they trigger memories of old wars. Following World War II, the ‘Japanese economic miracle’ alleviated the food crisis, and Western-style meals became an established food source, resulting in the culture of insects as a local food being diminished⁵⁾ and was only considered as an emergency food source.

Nutrient content of insects

The protein content of insects is high. For instance, proteins account for more than 50 % of the dry weight of grasshoppers and 68 % of locusts⁵⁾. Insect proteins are rich in amino acids such as leucine, isoleucine, lysine, and threonine and are low in methionine, histidine, and tryptophan. Since lysine and threonine are abundant in plants such as wheat, rice, corn, and cassava, an insect-based diet in areas where these are the staple foods is considered to be effective for incorporating deficient amino acids into the diets of locals⁵⁾. Insect fat contains a large amount of unsaturated fatty acids such as oleic acid, linoleic acid, and linoleic acid, and many insect species include arachidonic acid, eicosapentaenoic acid, and docosahexaenoic acid. Insects have low cholesterol levels, making them effective for low-cholesterol diets.

Many insects contain a majority of the essential vitamins, including vitamin A, B₁, B₂, and D. The pupae of silk moths are rich in vitamin A, grasshoppers are rich in vitamin B₂, and immature larvae of bees are rich in vitamin A and vitamin D. Honeybee larvae are said to contain about twice as much Vitamin A as egg yolk⁵⁾. Although it is only a small proportion of the dry weight, it also contains a relatively large amount of phosphorus. Essential minerals such as potassium, sodium, silica, aluminum, iron, calcium, magnesium, manganese, titanium, copper, and sulfur, have been detected in the component analysis of locusts⁵⁾. However, insects contain very little carbohydrates. Carbohydrates are abundant in chitin, which constitutes the exoskeleton of insects, but chitin is a sugar that cannot be digested by humans. , Since Japanese diets constitute a large number of carbohydrates, the lack of insect-based foods is compensated.

Focus and benefits of insects as food

The growing global population is believed to require more food than ever before. On the one hand, according to the “World Population Forecast” released by the United Nations in 2017, the world population of 7.6 billion is currently projected to reach 9.8 billion by 2050^{3),6)}. On the other hand, it is predicted that securing food and water resources will become a serious problem due to factors such as environmental pollution, global warming, and climate

change⁷⁾. Therefore, the Food and Agriculture Organization of the United Nations (FAO) is increasing its focus on insect-based food to mitigate future food problems⁴⁾. Generally, as the size of livestock increases (from chicken to pork to beef), more feed and water are needed. For example, to produce 1 kg of beef, approximately 8 kg of feed (grain) is required. On the other hand, 1 kg of insect meat can be produced with approximately 2 kg of feed^{1),6)}. By incorporating insects into the human diet, the time and effort spent on raising livestock for human consumption are reduced. It is also believed that pigs generate 10-100 times more greenhouse gases such as carbon dioxide than small creatures such as mealworms (*Tenebrionidae larvae*). Insect breeding can not only potentially reduce the burden on the environment and the amount of water used, but also the required land, compared to raising livestock. It may further, be possible to make future- and space food. If insects are cultivated, it is also noted that there is a little environmental burden until they can be harvested and eaten as food. Reduced environmental load to secure food sources of equivalent nutrition is insignificant from a United Nations SDGs (Sustainable Development Goals) perspective¹⁾. There are many advantages, including that the cultivation time for insects is much shorter than for other animals, the breeding efficiency is high, and artificial recycling is possible³⁾. Advances in biotechnology have also made artificial breeding much easier (at present, it means securing exhibits for zoos and testing animals for medicines and cosmetics). The cost reduction resulting from artificial feed production and the development of simple breeding methods are indispensable for the industrialization of food. This is, however, a challenging undertaking owing to the high costs associated with the current technology. Table 3 shows features such as the advantages and disadvantages of insect food.

Disadvantages of insects as a food source

There are several disadvantages of an insect as a food source. Firstly, apart from instances where insects are processed by individuals for self-consumption, commercially distributed insect food is expensive (at least in Japan)^{1),5)}. Entomophagy is not considered a common practice, and niche interests in it as a food source, their consumption and production are also small, and consequently, the production cost is high. Snacks containing insects are approximately four to five times more expensive than general ones, so they are not economically viable or easily accessible products. If the technology for cultivating edible insects develops in the future, it is expected that the production volume and efficiency will improve, and the price of insect-containing food will therefore gradually decrease.

Secondly, despite their small size, the nutritional value of insects is more than other animals. However, it is still necessary to ingest several insects to secure the nutrients in the necessary quantities. Conversely, overconsumption can lead to overnutrition, therefore, nutritional balance is vital. It is further necessary to adjust the amount and consume insects with other foods⁵⁾. Thirdly, insects could be an acquired taste, and may not be palatable to all^{1),8)}.

Fourth, it can cause allergies and other illnesses. It is difficult to ascertain what insects may have ingested, resulting in potential safety issues. For example, millipedes have an enzyme that makes hydrocyanic acid gas, and can potentially poison those who eat them live. Bees also have a protein poison. While this should not be harmful to the body as it is digested in the stomach, in rare cases it may cause shock. In addition, flies and cockroaches can carry pathogens such as *Escherichia coli*. It is strictly forbidden to eat these raw, and so must be cooked⁶⁾. Since insects are perishable, it is dangerous to pick up and cook dead insects. As long as insects are treated in a hygienic environment, disease transmission to humans is unlikely. Poisonous insects, and those that feed on poisonous flowers, should be avoided because they are chemically or bacteriologically toxic. Insects are closely related to shrimp and crabs, so they can also cause crustaceous allergies^{3),6)}. Since several disease-causing insects have been identified, there is, therefore, a possibility that the disease can be eliminated by selecting and culturing insects that are safe for consumption. Insects are relatively easy to collect individually, but it is difficult to secure a large number from the natural population for commercial purposes which leads to the destruction of the ecosystem. Artificial mass breeding of insects is necessary for food production. It will be challenging for people to get over their dislike for insects, but the development of cell culture techniques such as extracting and isolating the active ingredients of insects may enable mass production and overcoming the aversion in the future.

There still remains a dearth of information about entomophagy and its practicality. Future research must address the importance and scope of insect-based diets, as their popularity might be directly impacted by the information available^{3),9)}. Therefore, it is expected that the significance of proper insect food sources will only be made more popular if various aspects are clarified by research.

CONCLUSION

In Japan, there are many kinds of foods available, and in amounts considered to be relatively sufficient. As a result, it appears that insect-based foods are not commonly incorporated into the general diet of locals⁵⁾. Insects are not generally recognized as a source of food. However, powders and other foods that have been processed to a state where they are no longer recognizable as containing insects may be considered an emergency food source or a supplement for athletes due to their high nutritional value^{4),9)}. In Japan today, unlike most food, insect-based foods are not held to any proper standards, like the Japanese Agricultural Standard; the national standards concerning the quality of agriculture, forestry, fishery, and artificial products. In order to popularize insect-based food in Japan, standards need to be created as an initial step in the process⁶⁾.

In recent years, typhoons, heavy rains, and earthquakes have caused great damage to the agriculture and fisheries industry in Japan, and there are concerns about unstable food supply and soaring prices. In Japan, the self-sufficiency rate in terms of food production is low, and therefore, it is necessary to import from other countries. It is possible that food imports to Japan will decrease due to various reasons in the future⁶⁾. For example, global population growth is a problem that may result in a shortage of food sent to Japan. Japan should consider exploring the possibilities of diversifying food sources including insect-based foods and nutritional supplement methods in anticipation of unforeseen circumstances. It is considered difficult to change the taste preferences of Japanese people immediately, and it is necessary to gradually overcome the shortcomings and distribute an insect-based food that is safe. By limiting the types of insects and culturing them in a controlled environment, the influence of the insect's origin, the potential for poisoning can be eliminated, and quality deterioration due to rot can be prevented. Insect-based foods may also be unpleasant in taste and may contain very little carbohydrates, so it may be preferable to develop processed foods that use sugar, flour, and insects in production. Ultimately, insect-based foods will have to become more commonly available before being widely accepted as a food source¹⁾. Prior to that, it may be necessary to convince people to be more open to trying new sources of food. It is an indispensable factor in fully publicizing the merits of insect-based foods and spreading the use and acceptance of insect-based foods³⁾. It is unclear whether it is the price that will decrease or the consumption that will increase first, but it can be said that entomophagy will become more popular in the coming years.

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Table 1 Edible insects in the world

Country or region		Asia	Africa	North America	South America	Europa	Oceania	Japan
Orthoptera	Locust/grasshopper	Black	Black	White	Black	Black	Black	Black
	Cricket/mole cricket	Black	Black	White	Black	Black	Black	White
Cockroaches		Black	White	White	White	White	White	White
Hymenopterans	Honeybee/carpenter bee	Black	Black	Black	Black	White	White	Black
	Wasp	Black	White	White	White	White	White	Black
	Tailor ant/honey ant	Black	Black	Black	Black	Black	Black	White
Hemiptera	Cicada	Black	Black	Black	White	Black	Black	Black
	Giant water bug/stink bug	Black	Black	Black	Black	White	Black	White
Coleoptera	Scarab beetle	Black	Black	Black	Black	Black	Black	White
	Longhorn beetle	Black	Black	Black	White	Black	Black	Black
	Weevil/dung beetle	Black	Black	Black	White	Black	Black	White
	Water scavenger beetle/diving beetle	Black	Black	Black	Black	White	White	Black
Lepidoptera	Silkworm/carpenter moth	Black	White	White	White	White	Black	White
	Giant silkworm moth/hawk moth	White	White	Black	Black	White	White	White
Stoneflies		Black	White	White	White	White	White	Black
Caddisflies		Black	White	White	White	White	White	White
Dragonflies		Black	Black	Black	White	White	Black	White
Termites		Black	Black	White	Black	White	Black	White
Flies		Black	Black	Black	White	White	White	White

The black areas in the columns are the countries and regions where there a traditional culture of eating insects exists.

Based on survey results up to 1998⁵⁾.

Table 2 Edible insects in Japan

Region in Japan		Hokkaido and	Tohoku	Kanto	Chubu	Kinki	Chugoku	Shikoku	Kyushu	The whole of Japan 1998
Insects										
Orthoptera	Locust									
	Cricket									
	Mantis									?
	Mole cricket									
Hymenoptera	Bees (mainly larvae)									
	Ants									
Hemiptera	Cicada									
	Giant water bug (mainly eggs)									
Coleoptera	Longhorn beetle									
	Water scavenger beetle									
Lepidoptera	Silkworm									
	Two-brooded rice borer									?
	Pine hairy caterpillar									?

The black areas in the columns are the areas in Japan where there is a traditional culture of eating insects.

Based on findings up to 1946⁵⁾.

Data for the whole of Japan in 1998⁵⁾, based on information from Table 1.

Table 3 Advantages and disadvantages of insect-based foods

Periods of time	Benefit	Disadvantage	Others
From the past to the present (for residents in a limited area)	<ul style="list-style-type: none"> - It may be used to promote the country or region. - Other than in Japan, some foods are recognized as high in protein. 	<ul style="list-style-type: none"> - The parts of insects are discouraging (feet, wings, etc.). 	<ul style="list-style-type: none"> - It has a meaning as traditional or local food.
In recent years (for many ordinary citizens)	<ul style="list-style-type: none"> It- Not only high in protein but also contains most of the nutrients that people need. - Cultivation and harvesting times are short. - High breeding efficiency. - The amount of water and grains required for production is less than that of livestock. - It requires less land. - Environmental load (carbon dioxide emissions, etc.) is less than that of livestock. 	<ul style="list-style-type: none"> - Even a small number is very nutritious and eating until full can lead to overnutrition. - Eating a lot of wild insects as food may lead to the destruction of the ecosystem. For this reason, artificial breeding is essential. - Even if the citizen ingests it, it is not considered to be appealing. - In Japan, insect-based foods that are currently in general circulation are expensive. - It can cause diseases and allergies 	<ul style="list-style-type: none"> - It is attracting attention as a source of food for the future, as space food, or supplement for athletes. - It may be beneficial from the perspective of SDGs. - Currently, mass production has not been able to reduce costs. - In Japan, there are no insect-based food standards yet, and it is difficult to ensure safety. - It may be necessary to pay attention to the intake of processed foods imported from overseas. - It is better to avoid ingesting dead or raw insects.

Based on references 1), 4), 5) and 8).