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Common edible insects and their utilization in China

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Abstract

This paper reviews the common edible insects and their use in China. One-hundred and seventy-eight insect species from 96 genera, 53 families and 11 orders are commonly eaten in China. Preparation of edible insects includes frying, braising, stewing, stewing after frying, boiling and roasting. The insect forms eaten range from eggs to adults; however, in restaurants most are larvae and pupae. More than 50 species have been analyzed for their nutritive elements and nutritional value and these data are reviewed here. Insect health foods sold in the Chinese market are also briefly discussed.

Key words: China, common species, edible insects, nutritive value, utilization.

Introduction

China is one of the oldest countries that consumes edible insects. Eating insects in China dates back more than 3000 years. In Chinese ancient classical texts, not only have species of edible insects been recorded, but also the ways of catching and cooking them have been introduced (Chou 1980; Zhou 1982). As society developed and human living conditions improved, some knowledge of eating edible insects has been lost, but the custom of eating insects is still maintained in some places in China, especially in the minority areas of Yunnan Province of the southwest. The local minorities often serve edible insects such as bamboo insects, Chinese caterpillar fungus, locusts, ants, termites, bees, wasp larvae and silkworm pupae to important guests. Eating insects is very popular and they can be ordered at many restaurants all year round in Yunnan Province and other places in China.

Studies on insect nutritive elements have shown that insect bodies are rich in proteins, amino acids, fat, carbohydrates, vitamins and trace elements. Insects have attracted the attention of non-specialists and researchers as a complementary protein resource. As the human population increases, the lack of food resources has become increasingly problematic. It is therefore necessary to find and develop new food resources to meet requirements. Insects will be an important nutritional resource for humans and their production is worthy of development considering they have high nutritive value, are rich in species and there are huge insect populations.

Common species of edible insects in China

There are many species of edible insects in China. Different edible insects are consumed in different regions depending on the distribution of insects and local food preferences. It is believed that many edible insects do not have scientific names. At present, 178 common species of edible insects have been identified and named in China. They are from 96 genera, 53 families and 11 orders. Among them, the nutritive and mineral elements of more than 50 species have been analyzed (Chen & Feng 1999). Many common edible insects belong to Lepidoptera, Coleoptera and Hymenoptera. Four stages of insects are edible. However, larvae are most often consumed.

In Ephemerida, there are three to four edible species in China. *Ephemerella jianghongensis* is a common species. Local people use both naiads and adults as food in Yunnan, China. The nutritive elements of *E. jianghongensis* have been analyzed (Feng *et al.* 1999a).

Six to seven species of dragonfly larvae of Odonata are edible. The common species are *Crocothemis servilia*, *Gomphus cuneatus* and *Lestes praemorsa*. The nutritive elements of three species have been analyzed (Feng *et al.* 2001b). Naiad is the common stage for eating.

In Isoptera, sixteen species from three genera and two families are recorded as food. The nutritive elements of three species have been analyzed. The common species are *Macrotermes annandalei*, *M. barneyi*, *M. acrocephalus*, *Odontotermes formosanus*, *O. yunnanensis* and *Coptotermes formosanus* (Huang & Lin 1989; Lu *et al.* 1992). Local people often consume adult insects.

In Orthoptera, locusts and crickets are common edible insects. Nine species in eight genera and three families are edible. The nutritive elements of two species have been analyzed. The common species are *Oxya chinensis*, *Gryllotalpa orientalis*, *Gryllotalpa unispina*, *Gryllus bimaculatus* and *Tarbinskiellus portentosus* (Qiao *et al.* 1992; Chen & Feng 1999). Both nymphs and adults are edible after frying in oil.

Seven species from seven genera and five families are edible in Homoptera. The nutritive elements of four species have been analyzed. The common edible insect species are *Crytotympana atrata*, *Lawana imitata* and *Darthula hardwicki* (Feng *et al.* 1999b). Both nymphs and adults of edible insects in the order are edible.

Seven species from six genera and three families are edible in Hemiptera. The nutritive elements of four species have been analyzed. The common species are *Tessaratoma papillosa*, *Cyclopelta parva*, *Eusthenes saevus* and *Mictis tenebrosa* (Feng *et al.* 2000b). Both nymphs and adults of edible insects in the order are edible.

Common edible species in Coleoptera are *Stromatium longicone*, *Sphenoptera kozlovi*, *Tomcus piniperda*, *Oryctes rthinoceros* and *Cyrtotrachelus bugueti*. Thirty species from 25 genera and eleven families are recorded as food in China. The nutritive elements of 13 species have been analyzed (Liu *et al.* 1998; Ye *et al.* 1998; Chen & Feng 1999). Many kinds of larvae and adults in this order are edible. Most of them have however, not been studied and named scientifically.

Acanthacorydalis orientalis is only species in Megaloptera, which has been studied. The nutritive elements of *A. orientalis* have been analyzed (Feng *et al.* 1999a). Both nymphs and adults of this insect are edible.

The most edible insects are in Lepidoptera in 11 orders, with 70 species from 25 genera and 16 families. Many species are notable edible insects, such as Chinese caterpillar fungus, insect tea (made from the excrement of insects), bamboo insect *Chilo fuscidentalis* and silkworm *Bombyx mori*. The nutritive elements of 14 species have been analyzed (Dan *et al.* 1985; Shen & Luo 1991; Zhang *et al.* 1991; Zhou & Yang 1993; Zhu & Bao 1995; Chen & Feng, 1999; Feng *et al.* 2000a,b). In this order, larvae are mainly consumed. Silkworm pupae are also consumed.

In Diptera, two species from two genera and two families are consumed. The larva of housefly *Musca domestica* is commonly eaten. The nutritive elements of *M. domestica* have been analyzed (Li *et al.* 1997; Zhang & Yao 1997). The mass rearing method of the housefly has been well-developed in China.

In Hymenoptera, 32 species from nine genera and four families have been recorded. Edible wasps are the most common edible insects in summer in Yunnan. Larvae and pupae are often sold with the nest and eaten after deep frying. However, many kinds of edible wasps have not been studied and named. The nutritive elements of 20 species have been analyzed. The common species are bees (*Apis cerana*, *A. mellifera*, *Megapis dorsata*, *Micrapis florea*), ants (*Carebara lignata*, *Polyrhachis dives*, *Oecophylla smaragdina*, *Carebara lignata*) and wasps (*Vespa analis* Buysson, *V. basalis*, *V. bicolor*, *V. magnifica*, *V. sorror*) (Chen 1983; Rong *et al.* 1987; Wang *et al.* 1988; Shen & Luo 1991; Liu & Yuan 1997; Chen & Feng 1999; Feng *et al.* 2001c).

Nutritive value of edible insects

The nutritive elements of edible insects are analyzed by methods typically used for foods consumed in China. The nutritive value of edible insects is assessed by comparing them with other common foods. The chief contents are protein, amino acids, fat and fatty acids, carbohydrates, inorganic elements and vitamins.

Protein and amino acids

Insect bodies are rich in protein. In nearly 100 kinds of edible insects analyzed, at the egg, larva, pupa and adult stages, the raw protein content is generally 20–70%. The raw protein content of larva in Ephemeroptera is 66. 26%; Odonata larva, 40–65%; Homoptera larva and eggs, 40–57%; Hemiptera, 42–73%; Coleoptera larva, 23–66%; and Lepidoptera, 20–70%. The protein content of Formicidae in Hymenoptera is high (38–76%). The protein content of Apidae and Vespidae in Hymenoptera is 15–70%. According to analyzed data, the protein content of insects is obviously higher than in most plants. The protein content of some insects is also higher than that of chicken eggs, meat and fowl (Ramos-Elorduy & Pino Moreno 1989; Comby 1990; DeFoliart 1992; Mitsuhashi 1992; Hu 1996; Chen & Feng 1999; Yang 1998).

Protein is composed of more than 20 kinds of amino acids which benefit the human body. Of these, eight amino acids are necessary for human nutrition as they can not be synthesized in the human body. Analysis of more than 100 edible insects has shown that they contain the necessary amino acids content (10–30%), encompassing 35–50% of all kinds of amino acid, which is close to the amino acid model proposed by the Food and Agricultural Organization of the WHO. Parts of insects have similar protein contents and are comparable to good plant protein.

Fat and fatty acids

Fat is one of the main components of the human body. Fat stores and supplies energy as well as supports and protects different organs. Fat can also help in the absorption of vitamins. Phosphate, carbohydrate and cholesterol and similar fatty materials combined with protein are the components of many tissues and cells. They can form fat protein and cell membranes. Recent studies have shown that phosphatide can make grain healthy, reduce blood fat, clean cholesterol, cure fatty liver and cirrhosis, help cells and skin grow, and postpone senility. Fatty acids can be separated into saturated fatty acid and unsaturated fatty acids. Unsaturated fatty acids can help human growth, protect the skin, and reduce the formation of thrombus and clotting of blood platelets.

Reports and analyzed results (DeFoliart 1991; Chen & Feng 1999; Feng *et al.* 1999a,b, 2000a,b; 2001a,b,c; He *et al.* 1999; Lu *et al.* 1992) have shown that many edible insects are rich in fat. Their fat content is higher at the larva and pupa stages; at the adult stage, the fat content is relatively lower. For example, the fat content of *Oxya chinensis* adults (Orthoptera) is only 2.2%. Mostly, the fat content of edible insects is between 10–50%. Some larva and pupa of Lepidoptera have higher fat contents, such as *Pectinophora gossypeilla* (49. 48%) and *Ostrinia furnacalis* (46. 08%). The fatty acid content of edible insects is different from animal fat, as insects have a higher essential fatty acid content, which the human body needs. These fatty acids are found in the larva and pupa of *Dendrolimus houi*, larva of *Musca domestica*, *Chilo fuscidentalis* and in some ants. Therefore, the fat of edible insects has good nutritive value. Edible insects have similar lipid material, such as phosphatide, which has health benefits.

Carbohydrates

As one kind of animal food, edible insects are rich in protein and fat, but have lower amounts of carbohydrates. Types of edible insects differ; so too does the carbohydrate content (ranging 1–10%). An unusual source is insect tea, which has higher carbohydrate content (16.27%). Recent research reveals that insects have considerable amounts of polysaccharides, which can enhance the immunity function of the human body (Sun *et al.* 2007).

Chitin is a macromolecular compound that has high nutritive and health food values. As a kind of low caloric food, chitin also has medicinal value for it can stop bleeding, prevent thrombus and help heal wounds. More than 90% of insect skin is composed of chitin; different forms of edible insects have different chitin contents (5–15%), such as *Bombyx mori* dried pupa (3.73%), de-fatted pupa (5.55%), and *Dendrolimus houi* pupa (7.47%) and adult (17.83%) (He *et al.* 1999; Guo *et al.* 2008).

Inorganic salts and trace elements

Mineral element analyses have shown that edible insects are rich in nutritive elements such as potassium, sodium, calcium, copper, iron, zinc, manganese and phosphorus. Many edible insects are high in calcium, zinc and iron (Chen & Feng 1999).

Vitamins

Vitamins are a group of organic compounds that are necessary for metabolism in human bodies. As vitamins can not be synthesized in the human body, they must be supplied constantly by food. Studies on vitamins in edible insects are insufficient; however, edible insects contain carotene and vitamins A, B_1, B_2, B_6, D, E, K and C (DeFoliart 1991; Lu *et al.* 1992; Chen & Feng 1999; Feng *et al.* 1999b, 2000a,b; 2001a,b,c; He *et al.* 1999). For example, the vitamin A content of *Macrotermes annandalei* reaches 2500 IU/100 g; vitamin D, 8540 IU/100 g; Vitamin E, 1116. 5 mg/100 g; and the Vitamin C content of insect tea reaches 15.04 mg/100 g.

From the analyses above, it can be seen that insects are a good protein resource, in which there are rich proteins and amino acids, especially essential amino acids, for the human diet. Insects also can supply rich fat, fatty acids, nutritive elements, vitamins and carbohydrates, especially high unsaturated fatty acid, which has high nutritive value. There are other substances in insects which are good for human health; for example, anti-bacterial proteins and peptides, enzymes and hormones. Certain insects represent excellent health foods.

Utilization of edible insects

Edible insects are used as food in restaurants and as health foods in markets in China. There are 20–30 common species used in restaurants all year round. Popular edible insects are grasshoppers, silkworm pupae, wasps, bamboo insects and stink bugs. The most common ways of cooking insects are frying, deep-frying, quick-frying, braising, stewing, boiling, steaming and roasting. Edible insects are eaten in China as a kind of "mountain treasure food" now, although the insects were used as a food resource in ancient times. In cities people eat edible insects because they taste delicious and come from nature; this means there are no pesticides, no food additives and no other artificial materials. In minority groups, people eat insects as part of their custom. Edible insects illustrate diversity in food culture and attract increasing numbers of people to experience a minority culture.

Insects as health foods are derived from Chinese traditional medicine and some health functions have been confirmed by modern scientific research. There are some insects sold as health food in the market; the most famous is the Chinese caterpillar fungus, which is believed to enhance immunity and have anti-cancer properties (Toshio *et al.* 1977; Gong *et al.* 1990; Chen *et al.* 1997; Bok *et al.* 1999; Yoshikawa *et al.* 2004; Jia *et al.* 2005; Wang *et al.* 2005). Ant alcohol is another health food that comes from *Polyrhachis dives* dipped in alcohol. Research has shown that ant alcohol can enhance immunity and improve sexual ability (Chen *et al.* 2000, 2004; Liu *et al.* 2004). The active substances extracted from the male *Antheraea pernyi* moth are also a popular insect health food that has been recorded in Chinese traditional medicine to improve sexual ability. Research has shown that the termite *Macrotermes annandalei* can enhance immunity and has been processed to fine powder capsules in the market (Wu & Wang 1995, 1998). High protein and amino acid drinks or powder of edible insects have been studied.

It is difficult for most people to accepted insect as foods and eat them directly. People regard insects as dirty and scary, and they often refuse to eat them, despite the fact that insects have high nutritional value. Therefore, with the exception of eating insects directly in restaurants, insect food industrialization needs to change to overcome prejudices. For example, products could include fine insect powder, insect alcohol and nutritious insect liquids. Scientific tests on insect functional foods are needed confirm their health value and then fine insect foods can be processed using modern techniques.

Conclusion

Edible insects have been consumed in China since ancient times. One hundred and seventy-eight species of edible insects have now been studied and identified scientifically. However, there are many more edible insects than the recorded numbers, which means that more insects can be used as a human food resource. Edible insects are rich in protein, amino acids, some inorganic elements and vitamins. It is considered that insects can be used as future food to resolve global food shortages. Studies of insect food and its industrialization should be a future focus in order to utilize insects efficiently.

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