Chapter 2

Nutritional Value, Food Ingredients, Chemical and Species Composition of Edible Insects in China

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Additional information is available at the end of the chapter

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Abstract

As the prevailing food cultures, edible insects could be dated back to ancient China. It is becoming clear that insect resource can be mass-produced in sustainable development food utilization. China could introduce insects into modern western diets. It is a precious resource considering the nutritional value, food ingredients and chemical composition of species. Meanwhile, the edible insects' consumption also led to a challenge of addressing food security, nature conservation and the erosion of traditional food culture. We summarized the resourceful edible insects containing the nutrition substance, such as essential proteins, amino acids, fatty acids, carbohydrates, vitamins, mineral elements and other functional ingredients with the insect secondary metabolite, including the flavonoids, alkaloids, polysaccharides, hormones and phospholipids, which have high economic value for development and utilization.Based on the history, custom, plasmid resource, production and status of edible insects in China at present, it has been proven that the development of insects food well matches the need for human health in China.

Keywords: edible insects, sustainable resource food, nutritional value, active ingredients with the insect secondary metabolite, chemical composition, Chinese insect diet

1. Introduction

1.1. Discussing edible insect's resources value

Insects are most species-rich resources and one of the largest biological groups in earth organisms. With its wide resources, speed of reproductive growth, lower feed cost, edible insects are an important food source which has immense potential of the development and utilization. The edible insects contain the reasonable structure of nutrition, high nutritional value and numerous

functional factors. In addition, the current research results provided a reliable technical support for the large-scale production and processing of edible insects in factory production. Therefore, edible insects have a very broad prospect as food sustainable resources development in future.

1.2. Human insectivorous history and customs

Though insects actually could be used as the secured and sustainable food, people naturally disgust the pests and have the feeling that they will bring heavy disaster to human beings. Most people will feel incredible even nauseous if they see a person eating insects. Of course, for those who have tasted barbecue locusts' good things, situation is not so strange. However, in fact, if the history window of mankind is opened, we will find that insects occupy a prominent position in the human diet since the ancient times. Countries around the world in many parts of many societies used to have the habit of eating insects [1]. According to the literature reported, the Middle East people ate desert locusts before the 8th century BC [2–4]; in ancient Rome, people liked to eat a kind of larva of *Cossus cossus orientalis* Gaede and prompted to insect body hypertrophy using the flour [2]. In addition, the ancient Hebrew people hunt locusts for eating, American Indians ate the locust pest braised in soy sauce, Australian people loved eating cutworms, Africans fed termites, South Americans hobby to ten red ants and the Spanish make worm bean sauce from ant eggs, etc. Even up to now, the locusts have been accustomed to dry and grinded them into flour, baking cookies or bread sharing in Europe. African residents of some place even take ants, termites that make the taste delicious. In southern California and Mexico, American Indians collect a vast number of backstroke eggs in the water for consumption and sale. The blue butterfly Larvae are more popular in the United States and Mexico; their price is expensive and they are the famous rare dishes in restaurant or hotel. The edible insects also have a long history in China. In the third century BC, the emperor's banquet was made up of cicadas and bees such as Yiluan (ant egg sauce), Huangchong (locust pest), Mifeng (bee) and Chan (cicada), which had been listed as the emperor's own meat food and the banquet delicacy of aristocratic gatherings. There is a traditional Chinese famous specialty named Eight Jane Cakes from insects fly maggots [3]. In conclusion, the edible insects are rich whether they are in quantity or on people's table, including their nutritive value and medicinal value. These insects will play a very important role as a sustainable food resources development in the future. Edible insects from all over the world are listed in **Table 1**.

Insect	The state of edible insect	Countries and regions	Insect	The state of edible insect	Countries and regions
Locust (including migratory locust etc.)	Adult	China, Japan, Vietnam, Thailand, India	Leafspinner ant	Adult	Burma, Thailand, Australia, Malaysia
		Indonesia, America Mexico, Africa, Australia	Honey ant	Adult, larva	America, South Ameirica, Mexico
Gryllotalpa	Adult	China, Japan, Vietnam, Thailand	Cicada	Larva	China, Japan, South America, France

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Insect	The state of edible insect	Countries and regions	Insect	The state of edible insect	Countries and regions
Crickets (including oil. Reed big crickets, etc.)	Adult, larva	Indonesia, Japan, Thailand, Malaysia, America, Africa	Mayfly	Adult	China, Japan, Vietnam, America, Africa
Hawkmoth worm	Larva, pupa	China, Africa, Japan, America	Dragonfly	Adult, larva	Japan, Thailand, Indonesia, Africa
Slug moth	Pupa	China, Japan	Caddis worm	Adult, larva	Japan
Pine caterpillars	Larva, pupa	Japan, North Korea, Australia, Japan, America, Mexico	Osmanthus cicada (including negative ducking Rho)	Adult	China, Japan, Malaysia, Burma, Vietnam, Thailand, Australia, America
Noctuidae (cutworm)	Larva, pupa	Japan, South Africa, Australia, China	Aspongopus	Adult	China, India, Mexico, Africa
Locates the moth (including cordyceps sinensis)	Pupa	Japan, Thailand, Italy, Australia	Stinkbug	Adult	China, India, Africa
			Maggots	Larva	China, Japan, Africa, America
Carpenter moth	Larva	Africa			Mexico
Lappet moth	Larva	Africa	Ephydrid	Adult, larva	China, Japan, Thailand
White moth	Larva, pupa	Japan	Cockchafer	Adult, larva	Africa, America, France
Grape wing bug moths	Larva	Japan			Germany
Brahmaeidae	Larva	China, Japan			China, Japan, Thailand
Domain moth (backpack worm)	Adult, larva	Japan, Mexico	Longicorn beetle	Larva	Indonesia, Ceylon, Vietnam, Australia, Africa
Snout moth (including corn moth two group three moth, etc.)	Larva, pupa	Japan	Weevil	Larva	Indonesia, India, Thailand, Burma, Vietnam, Africa, China, Japan, America
Papilionid	Larva	Japan			Thailand, Africa
Skipper	Larva	Mexico	Buprestid beetle	Larva	China

Insect	The state of edible insect	Countries and regions	Insect	The state of edible insect	Countries and regions
Termite	Queen ant, Adult	China, Indonesia, India	Yellow mealworm	Pupa	Mexico
		Burma, Malaysia, Thailand	Tiger beetle	Pupa	China, Japan, Thailand
		Australia, Africa, South	Locust lang	Egg, adult	Australia, Africa
		America	Psylla head lice	Larva	
Ants	Adult	Indonesia, India, Thailand, Australia, Mexico, America	Head lice fleas	Adult	Indonesia, Vietnam, Africa, Mexico, South America
Hydrophilid	Adult	China, Japan			
Bagworm	Overwintering larvae	China	Red current worm	Overwintering larvae	China

Table 1. Edible insects from all over the world.

2. Development and utilization of edible insects resource

Edible insects can be divided into food insect, drug/medicinal insects and drug dual-use insects, etc., based on the different insects eaten resources classification. Edible insects are directly for a daily food consumption and the insect has important nutritional value to human to be developed and utilized. The U.N.'s Food and Agriculture Organization (FAO) has released a report in 2013 called Edible Insects: Future Prospects for Food and Feed Security [6]. It outlines the many benefits of eating insects—for human in the entire world. As early as 1980, it was put forward to supplement the human food shortage in the Fifth Latin American congress of Dietitians and Nutritionists, which should regard them that as part of food source insects as human food in many countries has been increasingly apparent at present.

Scientists have found that some insect protein from the red ants, grasshoppers and some of predaceous diving beetle (Dytiscidae)are enough to compete with lean beef.

The protein of adult insect content is rich, significantly higher than that of pork, beef, chicken, fish and eggs. Experts predict that insects will be the third category only after cell raw material and microbial protein sources in future [7]. As in poor regions, people need essential nutrients to provide, the services of the services of insect and spider equally good. And as in developed country like the USA, the insect and spider are the higher protein food from a healthy choice. Insects are a highly nutritious and healthy food source with high fat, protein, vitamin, fiber and mineral content [6]. "Gathering and farming

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insects can offer employment and cash income either at the household level or in larger industrial-scale operations." It could offer work to millions of people around the world. Besides, there is evidence that most of breeding insects produced the harmful greenhouse gases to the environment that may be less than those of livestock [8]. This result will help to decrease the cost of food production, reduce emissions from greenhouse gas. In recent years, along with the progress of modern science and technology, the process technology of the functional food and health-food markets of edible insects accelerates unprecedentedly in China. For example, concentrated insect protein oral liquid specialized in honey, royal jelly, pollen and propolis, the traditional shellac ash, etc. Insect oils of some are mainly used as the functional fat-soluble ingredients.

As mentioned above, insects are the largest species and biological organisms on earth. And their resources arre extremely rich. Moreover, its nutrition structure is reasonable with high nutritional value and many functional constituent; insects thus will be considered as an important food source for the development and utilization with huge potentials. Combined with the existing research results and their advantages of high reproductive growth speed and low feed cost, large-scale production provides a reliable technical support. The development and utilization of edible insect resources thus has a very broad prospect.

3. The value of nutrition and health benefits of edible insects

According to the records, about 3650 species of the edible insects have been found and used [8]. The advantages of edible insects in the food development, one highlights show, at the beginning of competing namely, already competed from widely distributed, best variety, fast reproduction, high nutritional value, breeding easy and high food conversion rate indistinct development competes for the sustainability in ecosystems and biodiversity. They thus have become an additional source of food with high nutritional value containing rich protein. At the same time, the insects' food has low fat and low cholesterol with a reasonable structure (less fleshy fiber) easily absorbed, and abundant trace elements, etc. It is, therefore, better than that of meat and eggs [9].

The results of research showed that edible insect contains various nutrient elements, such as protein, amino acids, fat, fatty acid, vitamins and mineral elements.

3.1. Edible insect protein

Onincx said "It proves the hypothesis that insects can be a more efficient source of protein, and I definitely believe there is a future for edible insects" [10]. Studies have shown that protein content is not the same for the different insect states. The protein content of adults is the highest, pupa is at second and larvae at the lowest. For wasps, the adult has 71.07%, pupa has 58.59% and a larva has 50.83% of protein content, according to the protein calculations of insects at different ages.

The protein content of different subjects' insect is not the same either. The Orthoptera is higher than Homoptera, higher than Odonata, Diptera, Hymenoptera, Hemipter, Lepidoptera and then Coleoptera insect [11].

Amino acid is the basic functional unit for biological macromolecular protein, and is also an important part of food constituted as insects' nutrition. The amino acid content of edible insects is 10–70%, and essential amino acid content is 10–30%. Most of the amino acid ratios for insect are appropriate and have approached or even exceeded that of the WHO/FAO required ratio. Study also revealed that the existence of large amount of free amino acids associated with insect freshness [6, 12]. The content of free amino acid of edible insects in the blood is about 3000–23400 mg/kg that is higher than any other higher animals of the universe.

3.2. Carbohydrate of edible insects

In addition to glucose, triose, glycogen, erythritol, ketose sugar, fructose and ketoheptose, edible insects' carbohydrates (sugars) sort are very rich and the sea algae sugar (insects' ingredient blood sugar) content is the same. Edible insects are easy to digest and absorb carbohydrates, and total sugar containing amount is generally as low as 1–10% or even lower [13]. For example, the total sugar content of *Cyclopelta parva* is 1.45%, and that of *Tessaratoma papillosa* is 0.15% [14].

Chitin is also the main material of edible insects' skin and bones. Its chemical name is N-acetyl-D-glucosamine copolymer with the function of adsorption abilities for a specific toxin. then, It is also a low calorie food that it has the very high nutrition value for the good for the health care. Chitin promotes intestinal peristalsis, fine regulating intestinal bacteria, reduce weight due to fat, anti-aging, enhance the immune function and assist in preventive treatment of high blood pressure, etc. Chitin is usually between 15 and 18%, rich in edible insect body. However, at different insect states, chitin content is different, such as the chitin content of dry silkworm pupa is 3.73% and Skim pupa's content reached 5.55% [3].

3.3. Mineral elements and vitamin of edible insects

Edible insects are rich in mineral elements, including Ca, P, Fe and zinc, etc., which are often needed as the supplement of human body. It is reported that feed insects can fulfill the requirement of animals' Fe, Cu, Zn and Mg mineral elements [15]. The locusts contain 27 kinds of mineral elements, notably Mn, Fe, Cu and Zn [16]. Many ants are rich in Zn, Se, Mn and Mg, etc. The level of Zn is two times more than pork liver, and eight times higher than soybean [17]. In addition to the constant element, edible insects are rich in Se, Co, Ni and Cd trace elements. The Chinese rice locust and yellow powder insect have Se content at 4.62 and 4.75 mg/kg,respectively. The Se element can accelerate detoxification, inhibit carcinogenic activity, destroy the carcinogen and prevent cancer cell growth and division. Other elements' content, such as Ni 1.22 mg/g, Co 1.36 mg/g and Cr 1.52 mg/g are reported in *Formica (Coptoformica) mesasiatica* Dlussky [3].

There are numerous vitamins in insect body, mainly including vitamin B1 (thiamine), B2 (riboflavin), B3 (niacin), B6 (pyridoxine), C, D, E, K and carotene. *Macrotermes annandalei* contains vitamin A 25.0, vitamin D 85.4 and vitamin E 11.7 I.U./g (International Unit/g). Vitamins are essential substances for maintaining normal physiological function of human body.

3.4. Lipid substances of edible insects

Insects are rich in oil and lipids. The fat content of pupae and larvae is higher than the adult insect. Report shows a decline in fat content after feather state of the insect. Fat content is commonly between 10 and 50% for edible insects. A recent study has found the fat content of wasp. In larvae, the fat content is 29.01%, while in pupae, it is 27.25% and in adults, it is for 17.22% [10]. Unsaturated fatty acid and palmitic acid are higher in edible insects. Among them, linolenic acid content is higher in Lepidoptera, and the oil acid content is higher in Coleoptera.

Related research also proved the variation in fat content for different species of insects. It is revealed that the fat content of Coleoptera is higher than that of Lepidoptera, Half wings, Hymenoptera, Odonata, Diptera and Orthoptera [19]. In fact, natural insect wax also contains a small amount of senior fatty acids. They can be used as pharmaceutical raw materials such as textile and stencil making model. Based on the infrared spectra analysis of insect wax, it was suggested that insect's wax is composed of mainly long-chain hydrocarbons, fatty alcohols, fatty acids and some compounds with aromatic rings mixture.

4. The nutritional evaluation of insect oil/fat

Insect oils (fat) are a kind of nutrient substances with several physiological and biological activities and functions. It has a high value of research, development and utilization no matter whatever be the quantity or quality. Fat content of insects' body changes with its life cycle, meanwhile it is closely related to the growing up of the insect species [20].

4.1. The oils and fats content in insects' body

Many studies have also displayed that the fat content of insects differed in the same species. The pupa and larva's oils (fat) were higher than adults' in the same species. And, during the winter period, the insects' oil contents were higher. The fat content of insects' dry body was commonly 10%, while many other insects have fat content of 30%, or even up to 77.16% (**Table 2**).

4.2. Fatty acid composition of insect oils and fats

Insects are rich in fat and their fatty acid composition is reasonable. The saturated fatty acids and unsaturated fatty acid ratio of edible insect is generally less than 0.4. Its partial fatty acid

Insect species	Crude fat %	Insect species	Crude fat %	Insect species	Crude fat %
Locates moth larvae	77.17	*Desert locust*	17	*Bollworm* larvae	49.48
		Asian corn borer larvae	46.08	The big spot *well-known*	14.5
Clanis bilineata	15.44	*Verdigris beetle* larvae	14.05	*Aprioma germari Hope*	41.46
Moths' larva	32.26			*stratiomyiid*	13.93
Mylabris cichorii	13.96	*Yellow mealworm* adult	19.23	*Pink neck sawyer* larve	35.89
Tussah male adult	39.49	*Oxya chinensis*	8.24	*Musca domestica* pupa	10.55
Cabbage worm	11.8	*Polyrhachis vicina* female	9.5	*Tussah* pupa	31.25
Tenebrio molitor L	28.8–34.0	*Holotrichia oblita* Fald	29.84	*Redchest* prickly ant adult	8.53
Polyrhachis vicina adult	8.57	*Housefly* larvae	12.61	*Convex star* flowers beetle larvae	19.35
Macrotermes annandalei	28.3	*Star longhorn* beetle larvae	35.19	*Green hsu* well-known	7.5
Epicauta chinensis	8.22	*Atractomorpha sinensis*	2.87–4.91	*Tussah cicada* larva	2.63
Wood stupid worm	26.46				
Acrida cinerea	2.89				

Table 2. Crude fat (dry weight) content (%) of some insects.

composition ratio is close to the fatty acid composition of fish proportion, and thus can be used as a natural health care product. The saturated fatty acids (SFA) of insects is mostly composed of the palmitic acid (C16:0) but not stearic acid (C18:0) which is relatively high in vertebrates. In addition, insect oil has the odd number carbon fatty acids rarely existing as the pentadecanoic acid and heptadecanoic acid that are relatively rare in the nature but extremely common in insects. As shown in **Table 2**, the heptadecanoic acid content of termites' adult, the housefly larvae and housefly adults were all above 2%. As odd number carbon fatty acid has special raw active function, it was found that they have stronger antitumor activity. Therefore, many researchers are very interested in insects' enrichment and separation of odd number carbon fatty acids, leading a hotspot in the research of the insect oil.

The insect oil is a solvent of natural active products containing the lecithin and fat-soluble D raw element (such as vitamin A, D, E). These active natural products have a strong physiological and biological function with the extremely important value.

	Composition of fatty acid										
Insect	**14:0**	**15:0**	**16:0**	**17:0**	**18:0**	**16:1**	**17:1**	**18:1$_{n-9}$**	**18:2$_{n-6}$**	**18:3$_{n-3}$**	**>18**
Larvae of *Tenebrio molitor*	0.51	0.99	23.6	–	1.4	1.8	2.7	44.7	24.1	1.5	–
House fly larvae	2.2	–	19.7	3.2	2.3	12.7	1.0	18.2	32.5	3.3	0.2
House fly adult	3.5	0.5	15.6	3.4	4.8	5.7	–	26.8	35.4	–	4.5
House fly pupa	0.7	2.1	27.6	–	2.2	5.8	14.8	18.3	14.9	2.1	0.2
Silkworm pupa	–	–	30.0	–	7.5	–	–	25.6	10.9	26.0	–
The termites adult	0.6	1.0	31.0	2.6	3.4	1.0	0.6	9.5	43.1	3.0	4.2

Table 3. The fatty acid composition of some of insects' oil and fats (%).

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4.3. The nutrition evaluation of insect oils

The fatty acid of insect oil and fats predominantly composes of unsaturated fatty acid and its proportion could be more than 60%, and can even reach up to 80% in some insects. The fatty acid of insect oil and fats predominantly composes of unsaturated fatty acid. And, its proportion could be more than 60%, and can even reach up to 80% in some insects. The fatty acid composition of some of the insects' oil and fats is shown in **Table 3**.

Among the unsaturated fatty acids (USFA) and monounsaturated fatty acids (MUFA) of insects, many oleic acid (C18:1) is a unique composition with the proportion at about 30 ± 10% or more. This is much close to fish food and better than poultry meat and eggs [5, 18, 20]. It is good for the health of human body. The bioactive mechanism of insects' fatty acid has been studied in the body and has proven the exact functional fatty acids physiological activity. It pointed out that the high linoleic acid content in certain insects has a close relationship with its strong reproductive functions. Research indicated that stearic acid could neutralize the nutritional effects, and the lauric acid (C12:0) and nutmeg acid (C14:0) can lead to the elevated level of the fatty acid of cholesterol. These kinds of saturated fatty acids (SFA) are low in insect oil.

Nutritionists believe that general proportion between the n-3 and n-6 (PUFA) should be based on the breast for 1:3–10 [21]. According to the best food and nutritional science, linoleic acid and linolenic acid are the essential fatty acids (EFA). These two kinds of fatty acids are obtained only from food directly. In case EFA is lacking, the oil should be restricted to oil's fatty acid with the low biological titer, and nutritional value is thus low. It can directly cause the growth retardation, reproductive barriers, skin damage (such as a skin rash), liver, kidney, nerve and visual diseases. The over-taken polyunsaturated fatty acids (PUSFA) can cause chronic hazards. Therefore, the world health organization (WHO) recommended a standard of food oil in adults, the recommended dietary fatty acids taken (1990) are produced by the percentage of the total energy, energy and food: fat 15–30%, of them SFA < 10, PUFA 3–7 [21].

In a word, insects have the characters of quick propagation, high content of fat composed of reasonable composition of fatty acids. They are thus a good edible oil resource with high quality.

5. The secondary metabolites of edible insects and potential medicinal substances

It has been proved by a large number of studies in recent years that the insect secondary metabolite is important sources to find new leading compounds. Arthropod natural products with insect constituent are structurally diverse, including compounds derived from fatty acid, polyketide, terpenoid, nucleoside and amino acid pathways. However, the biosynthesis of most of these compounds has not been studied in detail (**Figure 1**) [22]. Historically,

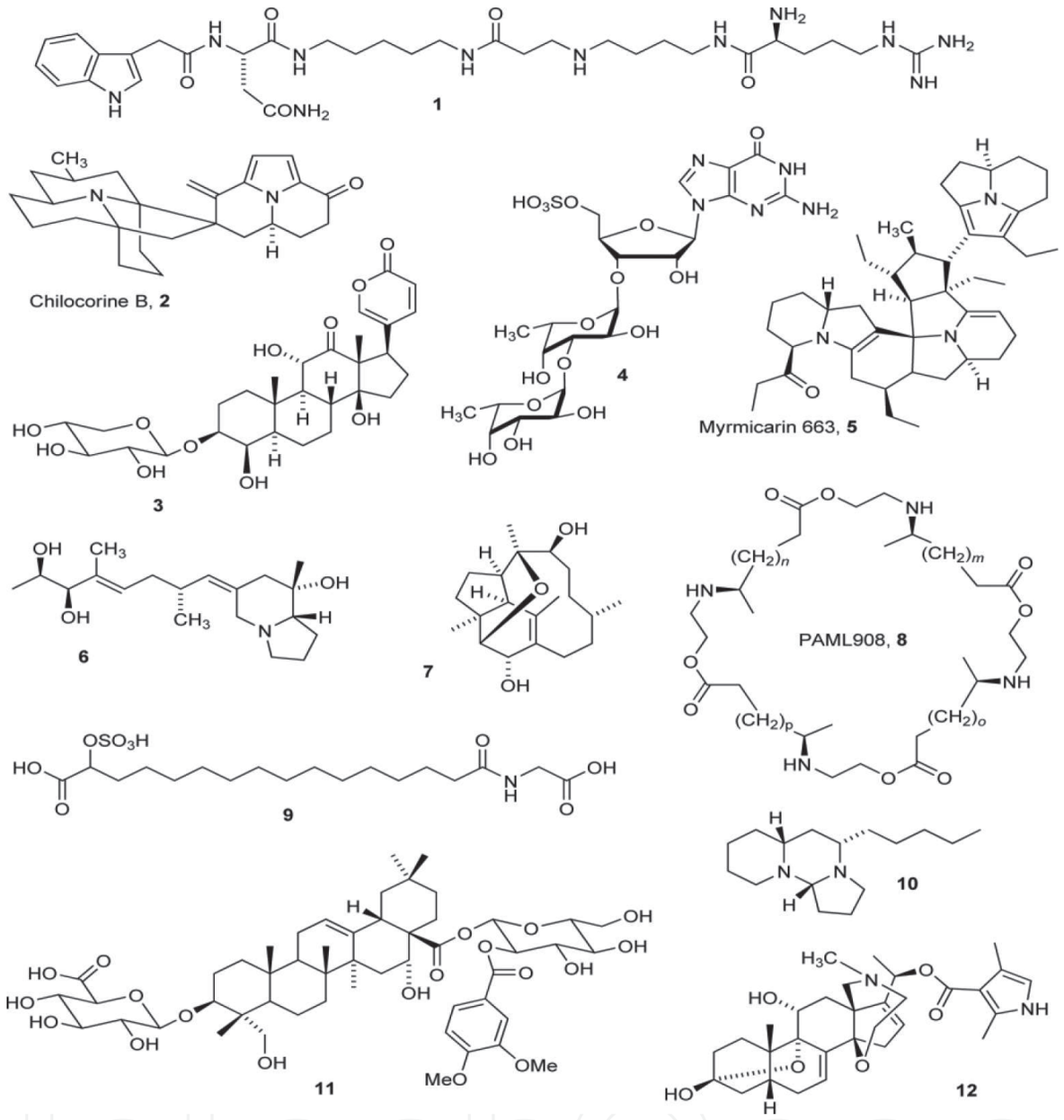

Figure 1. Examples of arthropod natural products from spiders (1, 4), mites (6), ants (5, 7, 10), fireflies (3), termites (7), grasshoppers (9), and beetles (2, 8, 11, 12).

traditional use of plants as medicines, known as "ethnobotany", has been extensively recognized and studied. It is worth noting that insects have been utilized as medicines in diverse cultures, especially in traditional Chinese medicines. It may be valuable for the development of the useful drugs. Another ongoing investigation by our group was the searching of new antibacterial structure from insects' natural products. More modern studies designed to determine the medicinal properties of isolated chemical components from insects and other arthropods will be performed.

6. Edible insects in China

According to the results of the survey, edible insect resources have been reported for more than 283 species with subspecies, involving 13 orders, 71 families in China [23]. Among them, the Orthoptera, Hemiptera, Coleoptera, Lepidoptera and Hymenoptera account for the majority number. Though most of the species have not been reported, the quantity of edible species identified is still growing. For this purpose, the author studied more than 283 species and subspecies of the edible insects in China. We recorded them as follows with * marked for the first-time report. China's edible insect species and their edible insects were discussed as follows:

1. Ephemerida

The order includes two families of the larva of Ephemerellidae and *Ephemerella jinghongensis* Xu et al.

2. Odonata

The order includes four families of Aeshnidae, Gomphidae, Libellulidae and Lestidae.

2.1. *Aeschnidae

The larva of **Anax parthenope julius* Brauer.

2.2. Gomphidae

The larva of *Gomphus cuneatus* Needham.

2.3. Libelluidae

1. The larva of *Crocothemis servilia* Drury.
2. The larva of * *Orthetrum albistylum* Selys.
3. The larva of * *Orthetrum triangula remelania* Selys.
4. The larva of * *Pantala flavescens* Fabricius.
5. The larva of * *Sympetrum uniforme* Selys.

2.4. Lestidae

The larva of *Lestes praemorsa* Sel.

3. Blattodea

The order includes two families of Blattidae and Corydiidae.

3.1. Blattidae

1. The nymphal/adult of *Periplaneta americana* L.
2. The nymphal/adult of *Periplaneta australasiae* L.

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3.2. Corydiidae

The nymphal/adult of *Eupolyphaga sinensis* Walker.

4. Mantodea

The order has only the Mantidae familie.

1. The nymphal/adult of *Mantis religiosa* L.
2. The nymphal/adult of *Paratenodera sinensis* Saussure.
3. The nymphal/adult of *Statilia maculata* Thunberg.
4. The nymphal/adult of *Tenodero bravico* Beier.
5. The nymphal/adult of *Tenodero sinensis* Saussure.

5. Isoptera

The order includes two families of Rhinotermitidae and Termitidae.

5.1. Rhinotermitidae

The larva/nest/adult of *Coptotermes formosanus* Shiraki.

5.2. Termitidae

1. The larva/nest/adult of *Macrotermes acrocephalus* Ping.
2. The larva/nest/adult of *Macrotermes annandalei* Slivestri.
3. The larva/nest/adult of *Macrotermes barneyi* Light.
4. The larva/nest/adult of *Macrotermes denticulatus* LietPing.
5. The larva/nest/adult of *Macrotermes jinhongensis* PingetLi.
6. The larva/nest/adult of *Macrotermes menglongensis* Han.
7. The larva/nest/adult of *Macrotermes yunnanensis* Han.
8. The larva/nest/adult of *Odontotermes angusti gnathus* TsaietChen.
9. The larva/nest/adult of *Odontotermes annulicornis* XiaetFan.
10. The larva/nest/adult of *Odontotermes conignathus* XiaetFan.
11. The larva/nest/adult of *Odontotermes formosanus* Shiraki.
12. The larva/nest/adult of *Odontotermes foveafrons* XiaetFan.
13. The larva/nest/adult of *Odontotermes gravelyi* Silvestri.
14. The larva/nest/adult of *Odontotermes hainanensis* Light.
15. The larva/nest/adult of *Odontotermes yunnanensis* TsaietChen.

6. Orthoptera

The order includes four families of Acridiidae, Gryllidae, Gryllotalpidae and Tettigoniidae.

6.1. Acridiidae

1. The nymphal/adult of *Acrida chinensis* Westwood.
2. The nymphal/adult of *Acrida. oxycephala* Pallas.
3. The nymphal/adult of *Acrida. turrita* L.
4. The nymphal/adult of *Arcyptera fusca* Pall.
5. The nymphal/adult of *Atractomorpha sinensis* Boliver.
6. The nymphal/adult of *Bryodema gebleri* FisherWaldheim
7. The nymphal/adult of *Calliptamus abbreviatus* Ikonn.
8. The nymphal/adult of *Calliptamus italicus* L.
9. The nymphal/adult of *Calliptamus barbaruscephalates* FisherWaldheim
10. The nymphal/adult of *Ceracris kiangsu* Tsai.
11. The nymphal/adult of *Chondracris rosea* DeGeer.
12. The nymphal/adult of *Dociostaurus kraussini grogeniculatus* Tar.
13. The nymphal/adult of *Gomphocerus sibiricus* L.
14. The nymphal/adult of *Locusta migratoria manilensis* Meyen.
15. The nymphal/adult of *Locusta migratoria migratoria* L.
16. The nymphal/adult of *Oedaleus decorus* Germ.
17. The nymphal/adult of *Oxya chinensis* Thunberg.
18. The nymphal/adult of *Oxya intericata* Stal.
19. The nymphal/adult of *Oxya japonica* Thunberg.
20. The nymphal/adult of *Pararcyptera microptera* FisherWaldheim.
21. The nymphal/adult of *Patanga japonica* Bolivar.
22. The nymphal/adult of *Skirakiacris shirakii* Bolivar.
23. The nymphal/adult of *Sphingonotus* spp.
24. The nymphal/adult of *Stauroderus scalaris* FisherWaldheim.

6.2. Gryllidae

1. The adult of *Brachytrupes portentosus* L.
2. The adult of *Gryllulus bimaculatus* DeGeer
3. The adult of *Gryllulus chinensis* Weber
4. The adult of *Gryllulus testaceus* Walker

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5. The nymphal/adult of *Teleoqzyllus derelictus* Gorochov.
6. The nymphal/adult of *Tarbinskiellus portentosus* (Lichtenstern).

6.3. Gryllotalpidae

1. The adult of *Gryllotalpa africana* Palisotde Beauvojs.
2. The adult of *Gryllotalpa orientalis* Burmeister.
3. The adult of *Gryllotalpa unispina* Saussure.

6.4. Tettigoniidae

The nymphal/adult of *Damalacantha vacca sinica* B. Bienko.

7. Homoptera

The order includes five families of Cicadidae, Coccidae, Flatidae, Membracidae and Pseudococcidae.

7.1. Cicadidae

1. The nymphal of *Cicada flammata* Dist.
2. The nymphal of *Cryptotympana atrata* Fabr.
3. The nymphal of *Platypleura kaempferi* Fabr.

7.2. Coccidae

The egg/adult of *Ericerus pela* Chavanness.

7.3. Flatidae

The nymphal of *Lawana imitata* Melichar.

7.4. Membracidae

The nymphal/adult of *Darthula hardwicki* Gray.

7.5. Pseudococcidae

The nymphal of *Phenacoccus prunicola* Borchs.

8. Hemiptera

The order includes five families of Belostomatidae, Coreidae, Corixidae, Noronectidae and Pentatomidae.

8.1. Belostomatidae

1. The nymphal/adult of *Kirkaldgia degrollei* Vuillefro.
2. The nymphal/adult of *Lethocerus indicus* Lepeletieret Serville.
3. The nymphal/adult of *Sphaerodema rustica* Fabricius.

8.2. Coreidae

The nymphal/adult of *Mictis tenebrosa* Fabricius.

8.3. Corixidae

1. The nymphal/adult of *Micromecta quadriseta* Lundblad.
2. The nymphal/adult of *Sigara substriata* Uhler.

8.4. Noronectidae

1. The nymphal/adult of *Anisops fieberi* Kirkaldy.
2. The nymphal/adult of *Enithares sinica* Stal.
3. The nymphal/adult of *Notonecta chinensis* Fallou.

8.5. Pentatomidae

1. The nymphal/adult of *Coridicus chinensis* Dallas.
2. The nymphal/adult of *Cyclopelta parva* Distant.
3. The nymphal/adult of *Erthesina fullo* Thunberg.
4. The nymphal/adult of *Eurostus validus* Dallas.
5. The nymphal/adult of *Eusthenes curpreus* Westwood.
6. The nymphal/adult of *Eusthenes saevus* Stal.
7. The nymphal/adult of *Nezara viridula* L.
8. The nymphal/adult of *Tessara toma papillosa* Drury.

9. Coleoptera

The order includes 15 families of Anobiidae, Bruchidae, Buprestidae, Cerambycidae, Crioceridae, Curculionidae, Dynastidae, Dytiscidae, Getoniidae, Hydrophilidae, Melolonthidae, Rutelidae, Scarabaeidae, Scolytidae and Tenebrionidae.

9.1. Anobiidae

The nymphal of *Lasioedrma serricorne* Fabricius.

9.2. Bruchidae

1. The nymphal/adult of *Bruchus pisorum* L.
2. The nymphal/adult of *Bruchus rufimanus* Boheman.

9.3. Buprestidae

1. The nymphal of *Chalcophora yunnana* Fairmaire.
2. The nymphal of *Coraebus sidae* Kerremans.

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3. The nymphal of *Coraebus sauteri* Oben.
4. The nymphal of *Sphenoptera kozlovi* B. Jak.

9.4. Cerambycidae

1. The nymphal/adult of *Anoplophora chinensis* Forster.
2. The nymphal/adult of *Anoplophora nobilis* Ganglbauer.
3. The nymphal/adult of *Apriona germari* Hope.
4. The nymphal/adult of *Aromia bungii* Faldermann.
5. The nymphal/adult of *Stromatium longicorne* Newman.
6. The nymphal/adult of *Psacothea hilaris* Pascoe.

9.5. Crioceridae

The nymphal/adult of *Sagra femorata purpurea* Lichtenstein.

9.6. Curculionidae

1. The nymphal/adult of *Cyrtotrachelus bugueti* Guer.
2. The nymphal/adult of *Cyrtotrachelus longimanus* Fabricius.
3. The nymphal/adult of *Macrochirus longipes* Drury.
4. The nymphal/adult of *Otidognathus davidis* Fabricius.

9.7. Dynastidae

1. The nymphal/adult of *Allomyrina dichotoma* L.
2. The nymphal/adult of *Oryctes rhinoceros* L.

9.8. Dytiscidae

1. The adult of *Cybister japonicus* Sharp.
2. The adult of *Cybister. limbatus* Fabricius.
3. The adult of *Cybister ripunctatus* Olivier.
4. The adult of *Eretes stictius* L.

9.9. Getoniidae

1. The nymphal/adult of *Dicranocephalus wallichi bowringi* Pascoe.
2. The nymphal/adult of *Oxycetonia jucunda* Faldermann.
3. The nymphal/adult of *Protaetia aerata* Erichson.

9. 10. Hydrophilidae

1. The adult of *Hydrophilus acuminatus* Motsch.
2. The adult of *Hydrous acuminatus* Motsch.
3. The adult of *Hydrous hastatus* Herbst.

9. 11. Melolonthidae

1. The nymphal/adult of *Holotrichia diomphalia* Bates.
2. The nymphal/adult of *Holotrichia lata* Brenske
3. The nymphal/adult of *Holotrichia oblita* Faldermann.
4. The nymphal/adult of *Holotrichia ovata* Chang.
5. The nymphal/adult of *Holotrichia parallela* Motsch.
6. The nymphal/adult of *Holotrichia sinensis* Hope.
7. The nymphal/adult of *Holotrichia srobiculata* Brenske.
8. The nymphal/adult of *Holotrichia szechuanensis* Chang.
9. The nymphal/adult of *Polyphylla laticollis* Lewis.

9. 12. Rutelidae

The nymphal/adult of *Anomala corpulenta* Mots.

9. 13. Scarabaeidae

The nymphal/adult of *Catharsiusmolossus* L.

9. 14. Scolytidae

1. The nymphal of *Sphaerotrypes yunnanensis* Tsaiet Yin.
2. The nymphal of *Tomicus piniperd* L.
3. The nymphal of *Xyleborus emarginatus* Eichhoff

9. 15. Tenebrionidae

1. The nymphal/pupa of *Tenebriomolitor* L.
2. The nymphal/pupa of *Tenebriomolitor obscurus* Feb.
3. The nymphal/pupa of *Tribolium confusum* Jac.du Val.

10. Megaloptera

The order has only the Corydalidae family.

The nymphal of *Acanthacoryda lisorientalis* Mclachlan.

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11. Lepidoptera

The order includes twenty-one families of Hesperiidae, Papilionidae et al.

11. 1. Hesperiidae

1. The pupa of *Erionota torus* Evans.

2. The pupa of *Parnara guttata* Bremeret Gray.

11. 2. Papilionidae

1. The pupa of *Papilio machaon* L.

2. The pupa of *Papilio polytes* L.

3. The pupa of *Papilio xuthus* L.

11. 3. Pieridae

The pupa of *Pieris rapae* L.

11. 4. Satyridae

The pupa of *Mycalesis gotoma* Moore.

11. 5. Aegeriidae

1. The larva/pupa of *Paranth reneregalis* Butler.

2. The larva/pupa of *Parathene tabaniformis* L.

11. 6. Bombycidae

1. The pupa of *Andraca bipunctata* Walker.

2. Silkworm chrysalis and silk moth of *Bombyx mori* L.

3. The pupa of *Theophila mandarina* Moore.

11. 7. Carposinidae

The pupa of *Carposina niponensis* Walsingham.

11. 8. Cossidae

1. The larva of *Cossus chinesis* Rothschild

2. The larva of *Cossus cossus* L.

3. The larva of *Cossus hunanensis* Daniel.

11. 9. Eucleidae

1. The pupa of *Cania bilineata* Walke.

2. The pupa of *Thosea sinensis* Walker.

11. 10. Gelechiidae

1. The larva/pupa of *Pectionophora gossyeilla* Saunders.
2. The larva/pupa of *Platyedra gossypiella* Saunders.

11. 11. Geometridae

The larva/pupa of *Biston marginata* Matsmura.

11. 12. Hepialidae

1. The larva/pupa of *Hepialus albipictus* Yang.
2. The larva/pupa of *Hepialus altaicola* Wang.
3. The larva/pupa of *Hepialus armoricanus* Oberthur.
4. The larva/pupa of *Hepialus baimaensis* Liang.
5. The larva/pupa of *Hepialus cingulatus* Yang et Zhang.
6. The larva/pupa of *Hepialus deudi* Poujade.
7. The larva/pupa of *Hepialus deqinensis* Liang.
8. The larva/pupa of *Hepialus dongyuensis* Liang.
9. The larva/pupa of *Hepialus ferrugineus* Li, Yang et Shen.
10. The larva/pupa of *Hepialus ganna* Hubner.
11. The larva/pupa of *Hepialus gonggaensis* FuetHuang.
12. The larva/pupa of *Hepialus jinshaensis* Yang.
13. The larva/pupa of *Hepialus kangdingensis* Chu et Wang.
14. The larva/pupa of *Hepialus kangdingroides* Chu et Wang.
15. The larva/pupa of *Hepialus lijiangensis* Chu et Wang.
16. The larva/pupa of *Hepialus litangensis* Liang.
17. The larva/pupa of *Hepialus luquensis* Yang et Yang.
18. The larva/pupa of *Hepialus macilentus* Lversmann.
19. The larva/pupa of *Hepialus markamensis* Yang, Li et Shen.
20. The larva/pupa of *Hepialus meiliensis* Liang.
21. The larva/pupa of *Hepialus menyuanensis* Chu et Wang.
22. The larva/pupa of *Hepialus nebulosus* Alpheraky.
23. The larva/pupa of *Hepialus oblifurcus* Chu et Wang.
24. The larva/pupa of *Hepialus pratensis* Yang.

25. The larva/pupa of *Hepialus renzhiensis* Yang.
26. The larva/pupa of *Hepialus H.sichuanus* Chu et Wang.
27. The larva/pupa of *Hepialus varians* Staudinger.
28. The larva/pupa of *Hepialus xunhuaensis*Yang et Yang.
29. The larva/pupa of *Hepialus yeriensis* Liang.
30. The larva/pupa of *Hepialus yulongensis* Liang.
31. The larva/pupa of *Hepialus yunlongensis* Chu et Wang.
32. The larva/pupa of *Hepialus yunnanensis* Yang et Li.
33. The larva/pupa of *Hepialus yushuensis* Chu et Wang.
34. The larva/pupa of *Hepialus zhangmoensis* Chu et Wang.
35. The larva/pupa of *Hepialus zhayuensis* Chu et Wang.
36. The larva/pupa of *Hepialus.zhongzhiensis* Liang.
37. The larva/pupa of *Napialus hunanensis* Chu et Wang.

11. 13. Lasiocampidae

1. The adult/pupa of *Dendrolimus houi* Lajonquiere.
2. The adult/pupa of *Dendrolimus kikuchii* Matsumura.
3. The adult/pupa of *Dendrolimus punctatus* Walker.
4. The adult/pupa of *Dendrolimus punctatus wenshanensis* Tsai et Liu.
5. The adult/pupa of *Dendrolimus superans* Butler.

11. 14. Noctuidae

1. The pupa of *Agrotis ipsilon* Pottemberg.
2. The pupa of *Anomis flava* Fabr.
3. The pupa of *Heliothis armigera* Hubner.
4. The pupa of *Hydrillodes morosa* Butler.
5. The pupa of *Laphygma exigua* Hubner.
6. The pupa of *Leucania separata* Walker.
7. The pupa of *Naranga aenescens* Moore.
8. The pupa of *Prodenia litura* Fabr.
9. The larva/pupa of *Sesamia inferens* Walker.

11. 15. Notodontidae

1. The adult/pupa of *Leucodonta bicoloria* Denis et Schiffermuller.
2. The adult/pupa of *Notodonta dembowskii* Oberthuer.
3. The adult/pupa of *Phalera assimilis* Bremer et Gray.
4. The adult/pupa of *Phalera bucephala* L.
5. The adult/pupa of *Semidonta biloba* Oberthuer.

11. 16. Psychidae

The larve/pupa of *Psychidae* spp.

11. 17. Pyralidae

1. Insect tea of larva feces for *Aglossa dimidiata* Haworth.
2. The larva/pupa of *Chilo suppressalis* Walker.
3. The larva of *Chilo fuscidentalis* Hampson.
4. The larva/pupa of *Chilo* sp. (English named, Bamboo maggots)
5. The pupa of *Cnaphalocrocism edinalis* Guenée.
6. The pupa of *Dichocrocis punctiferalis* Guenée.
7. The larva/pupa of *Ostrinia furnalis* Guenée.
8. The pupa of *Plodia interpunctella* Hubner.
9. The pupa of *Sylepta derogata* Fabr.
10. The larva/pupa of *Tryporyza incertulas* Walker.

11. 18. Saturniidae

1. The larva/pupa of *Antheraea pernyi* Geurin.
2. The larva/pupa of *Philosamia cynthia* Drury.

11. 19. Sphingidae

1. The larva/pupa of *Clanis bilineata* Walker.
2. The larva/pupa of *Clanis deucalion* Walker.
3. The larva/pupa of *Herse convolvuli* L.
4. The larva/pupa of *Smerithus plannus* Walker.

11. 20. Tortrcidae

The pupa of *Leguminivora glycinivorella* Matsumura.

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11. 21. Xyloryctidae

1. The pupa of *Linoclostis gonatias* Meyrick.
2. The pupa of *Xyloryctidae* spp.

12. Diptera

The order includes three familie of Muscidae, Sarcophagidge and Tipulidae.

12. 1. Muscidae

The egg/larva of *Musca domestica* L.

12. 2. Sarcophagidge

The larva of *Sarcophagidae* spp.

12. 3. Tipulidae

The larva of *Tipula paltudosa* Meig.

13. Hymenoptera

The order includes seven families of Agaonidae, Apidae, Polistidae, Sco1iidae, Sphecidae, Vespidae and Formicidae.

13. 1. Agaonidae

The egg/larva/pupa/adult of *Blastophaga pumilae* Hill.

13. 2. Apidae

1. The larva/pupa of *Apis cerana* Fabricius.
2. The larva/pupa of *Apis mellifera* L.
3. The larva/pupa of *Bombus speciosus* Smith.
4. The larva/pupa of *Megapis dorsata* Fabricius.
5. The larva/pupa of *Megapis florae* Fabricius.

13. 3. Polistidae

1. The larva/pupa of *Polistes antenalis* Perez.
2. The larva/pupa of *Polistes chinensis* Fabricius.
3. The larva/pupa of *Polistes gigas* Kirby.
4. The larva/pupa of *Polistes hebraeus* Fabricius.
5. The larva/pupa of *Polistes mandarimnus* Saussure.
6. The larva/pupa of *Polistes.sagittarius* Sassuer.
7. The larva/pupa of *Polistes salcatus* Smith.

13. 4. Sco1iidae

The larva/pupat of *Scoliidae* spp.

13. 5. Sphecidae

The larva/pupat of *Sphecidae* spp.

13. 6. Vespidae

1. The larva/pupa of *Provespa barthelemyi* Buysson.
2. The larva/pupa of *Vespa analis* Buysson.
3. The larva/pupa of *Vespa basalis* Smith.
4. The larva/pupa of *Vespa bicolor bicolor* Fabricius.
5. The larva/pupa of *Vespa crabro* L.
6. The larva/pupa of *Vespa ducalis* Smith.
7. The larva/pupa of *Vespa mandarinia* Smith.
8. The larva/pupa of *Vespa sorror* Buysson.
9. The larva/pupa of *Vespa tropica ducalis* Smith.
10. The larva/pupa of *Vespa variabilis* Buysson.
11. The larva/pupa of *Vespa velutina auraria* Smith.
12. The larva/pupa of *Vespa* spp.

13. 7. Formicidae

1. The egg/larva/pupa/adult of *Camponotus japonicus* Mayer.
2. The egg/larva/pupa/adult of *Carebara lignata* Westwood.
3. The larva/pupa of *Formica rufa* L.
4. The larva/pupa of *Formica aquilonia* Yarrow.
5. The larva/pupa of *Formica beijingensis* Wu.
6. The larva/pupa of *Formica fusca* L.
7. The larva/pupa of *Formica japonica* Mottschulsky.
8. The larva/pupa of *Formica sanguinea* Latr.
9. The larva/pupa of *Formica uralensis* Ruzsky.
10. The larva/pupa of *Formica yessensis* Forel.
11. The larva/pupa of *Lasius flavus* Fabricius.
12. The larva/pupa of *Oecophylla smaragdina* Fabricius.
13. The egg/larva/pupa/adult of *Polyrhachis dives* Smith.

14. The larva/pupa of *Polyrhachis illaudata* Walker.
15. The egg/larva/pupa/adult of *Polyrhachis lamellidens* Smith.
16. The egg/larva/pupa/adult of *Polyrhachis vicina* Roger.
17. The egg/larva/pupa/adult of *Tetramorium caespitum* L.

7. Insectivorous culture as sustainable development of food in China

China has a long insectivorous culture and important insect food resources. The characteristics of insect diversity and high nutritional value promise the great potentials to utilize these precious resources. At present, the development and utilization of China's edible insects are mainly in two aspects: the insect dishes and insect protein products.

7.1. Insect dishes in China quickens your appetite

Chinese insect dishes and foods often include traditional and innovative ways of two eating, such as oil silkworm chrysalis, Cicada Fried Crispy Fried locust Lang, Chinese caterpillar fungus duck and Tremella silkworm chrysalis, etc. Also, the insects could be used as ingredients for bread, insect drinks and wine. Edible insects can also be processed into insect nutrients liquid and health products as the main raw materials that are currently fashionable gifts to share for human health. And, most of this kind of products in China are listed as follows: The proteolytic enzyme of honeybee pupa and Bee pupa drinking; Royal Jelly Capsules, Royal jelly cream and Royal jelly powder; Drone pupa wine, Gekko-drone wine which is prepared with Gekko, drone pupa, Lycium chinense and rice wine and through twice soaking. Tussah pupa protein drink for quick nutrition supplement; Amino acid drink of yellow powder insect caterpillar protein; Amino acid drink of sweet potato hawkmoth canned; Soy sauce of silkworm chrysalis; Dry bread cake of silkworm chrysalis protein; Silk protein beverage and jelly, silkworm moth oil and wine, etc. In addition, the raw materials of nutritional health products used more ants as well, which will satisfy the demands of treating different diseases like tracheitis, active chronic gastritis, dysmenorrhea, psychoneurosis, pulmonary tuberculosis, alopeci and impotence, etc.

7.2. The development of insect protein products in China

The fly pupae are mainly used as raw material to develop traditional curative food and make the high protein food through processing. These research works currently focus on the development and utilization of several kinds of insects: flies, locust, cicadas and silkworms and so on. Then, this kind of eating insects is rich in protein, which can be compared to other foods such as meat and eggs. They can, not only solve the food shortage, but also food crisis of global food inequality in the near future.

Extensive and profound Chinese food culture is glamorous. The miracle of insectivorous culture refers to a gorgeous art of diet culture treasure in China. At once, as one of the most urgent tasks in the development and utilization of insects, edible insects can be converted to a steady stream of elegant food dedicated to all humanity.

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