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Medicinal and Analytical Chemistry International Journal
ISSN: 2639-2534

The Economic Importance of Insects: A Comprehensive Review

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Mini Review

Volume 7 Issue 2

Received Date: August 14, 2023

Published Date: December 21, 2023

DOI: 10.23880/macij-16000185

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Abstract

Insects are regarded as the largest group of arthropods on earth. They are easy to breed and have a large population due to their high fecundity and species diversity. Though a lot of people are aware of honey and silk as products from beneficial insects, many people are also unaware of other products like wax, Lac, gall aphid and their uses. Insect breeding and their industrial uses have attracted much attention in different countries across the world.

Insects are often reared for the biological control of agricultural and sanitary pests. Some other insects serve as chemical raw materials for industries. In agriculture, insects are used as pollinators and to increase the yield of crops Scorpion venom and oily substances from blister beetles and other insects are used as medicine. In this comprehensive review article, we have fully examined the use of insects in the industry.

Keywords: Insects as Medicine; Insects in Industry; Economic Insects; Insect Products; Pollination; Biological Control

Introduction

The two main factors that have caused humans to seek refuge in insects are the Number of insect species on Earth is estimated at 2 to 3 million, which probably accounts for more than 90% of all animal species [1,2].

Insects are the most diverse and populated category of animals. Since the time search for industrial revolution and their ever-increasing population on the planet. Of the approximately 1,900 insect species reported for humans uses. It is mostly consumed in Asia and Central Asia and Central America, with about 2 billion people in 113 countries. Eating insects regularly as part of their cultural habit and meal [3].

The total humankind began their primitive lives in small communities by the rivers, it was realized that the number of arthropods was very large, and as such could be used as food or raw materials for making clothes, etc [4,5].

Now, with the industrial and scientific advancements, versus the massive increase in human population, the importance of a dense population cannot be overemphasized. Today, many industries provide the needed comfort to humans. In fact, an industry is a group of companies whose services and products are largely substituted to satisfy the

basic needs of customers [5].

Some of the industries where insects are often used are food, pharmaceutical, health, textile, commercial trade, agriculture, livestock and poultry, medical and laboratory engineering, military engineering, tourism, and jewelry, etc [5,6].

Food industry

Experts have predicted that by 2050, the world's population will reach 11 billion [7]. As such, feeding a huge population with limited supply of food may become extremely difficult. Therefore, the world may have to rely on the consumption of insects as food supplements. Insects are a preferred choice because they are cosmopolitan, reproduce quickly, have high growth and adaptability, and are economical to be used as high protein sources of food [8].

Wade, et al. elucidated the scale of industrialization of edible insects from (a) the microbiological level of insect breeding, to (b) the external production factors within breeding facilities, (c) development of insect products, (d) adoption of consumers in industry-bred insects and (e) social and ethical concerns with the industry [9].

Cochineal

Cochineal, a red dye made from bugs in the laboratory, is used to color food and cosmetics [10]. Carminic acid is traditionally extracted from a type of insect [10].

Cochineal bugs

Scale insects are about 2.5 inches long. These insects were collected and dried from cacti in ancient India and then turned into natural dyes such as cochineal extract and carminic acid.

Rasmus JN Frandsen biologist of the Technical University of Denmark states that this red color was extracted from an insect of the genus *Kermes* genus [10] (Figure 1).

Figure 1: Red dye extracted from cochineal insect [11].

Between 1967 and 2009, the Food and Drug Administration of the United States of America has confirmed that the extracts of carminal and carminic are used for various purposes. They are used to color yogurt, cakes, types of chocolate, and meats [10].

Today, Peru is the largest commercial producer of *D. coccus*, followed by Mexico, Chile, Argentina, and the Spanish Canary Islands (a). This insect reared on plants like Prickly pear (also known as cactus pear or nopal) of the genus *Opuntia* (Figure 2) [10].

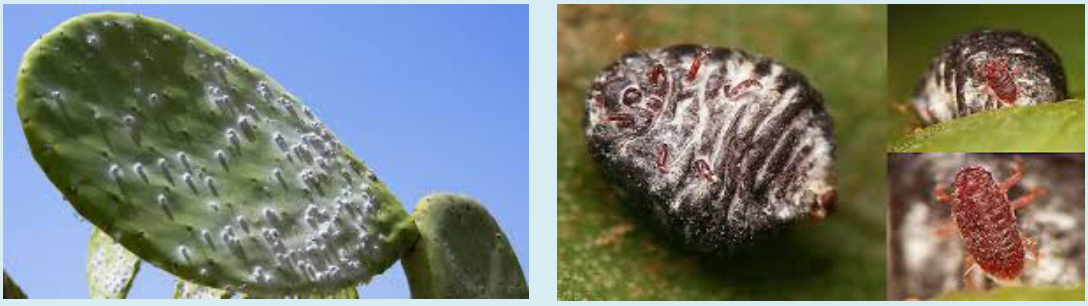

Figure 2: A: Cochineal scale on Cactus pad. B: Cochineal (*Dactylopius coccus*) [11].

Human Food

Edible insects are rich in protein (50-82%) [12-14], calcium, iron and zinc [15]. These nutrient-rich biomasses make them a vital source of ingredients in human and animal nutrition [16,17]. Insect consumption, also called insectivory is traditionally practiced by more than two billion people across the world, mostly Asia, Africa and South America. Of the over 1,900 edible species described in scientific literature, 31% are beetles (Coleoptera), 18% are moths

and butterflies (Lepidoptera), 14% are bees, wasps and ants (Hymenoptera) and 13% are Grasshoppers, locusts and crickets (Orthoptera) [18,19]. The consumption of insects is a completely unfamiliar practice in Western countries [4]. Even though edible insects are mainly found in Africa, Europe and the United States currently have the fastest growing formal edible insect industries [20]. According to Patel, et al. insect-based foods are in a transition stage [21].

Many countries in Asia, Oceania, Africa and Latin America use insects as their main source of protein. The use of insects as food can potentially solve problems related to conventional food supply chains, including global water, land and energy scarcity [22].

Academia, industries and governments have attempted to reduce the negative perception of insect consumption through the development of acceptable processing methods and products. Additionally, they provide explanations on health benefits of insect consumption and the need to reduce overdependence on other food sources [22].

As a result, about 500 species from almost 260 genera and 70 families of insects are used for human food elsewhere in the world, especially in Central and South Africa, Asia, Australia and Latin America. Insect consumption provides 5-10% of annual animal protein for indigenous people [5].

In Thailand for instance, a specific sex pheromone gland in the giant bed bugs provides flavored water for shrimp paste. Thus, though the marketing of insect-derived foods in selected regions of the world contributes to such local economies, the high consumption of insect foods as is the practice in western countries neutralizes the economic opportunity of mass production and marketing of these products [5].

Edible insects can upgrade low-grade side streams of food production into high-quality protein, amino acids and vitamins in a very efficient way. Insects are considered to be the “missing link” in the food chain of a circular and sustainable economy. Insects and insect-derived products have entered the European market since first being acknowledged as a valuable protein source for feed and food production in around 2010 [23].

Edible insects are more likely to be eaten, if processed into unrecognizable forms. Therefore, insect food products need to undergo commercial processing methods that make the protein suitable for food/feed formulation, while maintaining the safety, nutritional and sensory quality of the final product. Common methods that can be used include lipid extraction, enzymatic proteolysis, commercial thermal processing (e.g. commercial blanching, pasteurization and sterilization), low temperature processing (refrigeration and freezing), and dehydration and fermentation technology. Each method has advantages and disadvantages that must be carefully considered because not all methods and/or processing conditions are applicable to all edible insects or insect flour [24].

Damsel flies: These are usually fried or grilled with a taste similar to ginger and garlic. Damsel flies are also consumed in the Sirjan city of Kerman, Iran [25,26]. Evidence available suggests that locusts are a delicacy in Khorasan (Nishabur, Birjand, Qain and Sabzevar), Kerman (Sirjan, Shahr-e-babak, Zaidabad and Baft) and Fars (Garash and Ahvaz) provinces of Iran. During the Second World War in 1943, people consumed roasted locusts and cicadas as food, to satisfy their hunger; and that gradually became the food culture of those regions [25,26].

Animal Feed and Pets

Livestock consume approximately 20% of global protein and compete with humans for ocean fish stocks, water resources, land and soil [27]. Poultry, pigs, fish and some pets are fed diets containing fishmeal and fish oil, which are made from ocean-caught fish and fish flakes. Aquaculture plays a vital role in human nutrition and is growing faster than any other protein source for human consumption. Almost half of the fish we eat today comes from farmed sources [26]. However, fish meal, the primary food source for farmed fish is in crisis because it comes from ocean fish stocks. By replacing traditional animal and fish diets with insect protein, we can offset the increasing competition for ocean fish stocks needed to feed an additional 2 billion people, by 2050 [28].

Among the advantages of using insects to feed livestock are the high nutritional value, feeding efficiency and the reproductive capacity of the animals. Insects have the ability to produce by-products. They are naturally present in some livestock diets like fish, poultry and pigs, and can provide additional socio-economic and environmental benefits [29,30]. There is a wide range of suitable insects, e.g. Black soldier fly (BSF) larvae, housefly maggots, mealworms, silkworms and grasshoppers, grasshoppers and crickets [31-34].

The Lac Insects

Lac is a natural resin that is secreted by female adults of the lac insect [6]. Lac extracted from some species of the genus Kerria [35]. Lac is commercially produced in southeastern Asian countries, including China (Kerria yunnanensis), India (K. lacca), Thailand (K. chinensis), and Myanmar (K. nepalensis) [35]. In general, Lac has three main

components, i.e. paint, resin and shell wax [31].

Medicine and Health Industries

Royal jelly: Royal jelly, a substance secreted by the hypo pharyngeal glands of worker bees, stimulates the growth and development of queen bees. It revives the body of queen bees and increases their life span. Pantothenic acid, a major ingredient of royal jelly, is useful for the treatment of certain bone and joint disorders. Symptoms of rheumatoid arthritis may be reduced by injecting patients with this acid. Even better results were reported when pantothenic acid was combined with royal jelly. This product is sold by health food companies [36].

Honey bee: The glands in the abdomen of young worker honey bees secrete small waxy platelets, composed of combs of hexagonal cells and filled with honey that can be used to hold back the larvae. When sealed with additional wax, honey bees can be used for storage. Of all the main bee products, wax has been the most versatile and widely used material [37].

Honey bee: It is one of the most common insect pollinators. Some of the activities of honey bees in the commercial field include creating commercial apiaries and employing bees to pollinate alfalfa, tomato, apple and other plants. Among the several uses, honey bees can also be used as therapeutic venom, embryo gel and pollen in the treatment of various diseases [37-41].

Killer bees: They are used to scare elephants from entering the field. Killer bees can be controlled by sterilizing the male insects, Mediterranean fruit flies, etc [39].

Royal jelly: Royal jelly constitutes one of the richest natural sources of pantothenic acid (vitamin B5). Secreted by worker bees, the vitamin is expensive and is very useful in treating some bone and joint disorders. It reduces the severity of rheumatoid arthritis [36].

Entomological Warfare

Entomological warfare (EW) is a type of biological warfare that uses insects to disrupt supply lines by damaging crops or directly harming enemy combatants and civilian populations [42].

Insect-borne diseases have killed many soldiers throughout the ages. Across the world, millions of people have been infected with malaria, yellow fever, dengue, and a host of other mosquito-borne diseases [43]. For the first time in the 14th century, the Tartar army threw plague-infected corpses into the city with a catapult; they relied on fleas as an effective means to fight their enemies. During the World War II, the Japanese used 500 million fleas carrying the plague bacillus as a weapon of war. In 1950, the United States was accused of dropping Colorado potato beetles over East Germany. About 14 other insects were used in the Korean War [43].

Lipdopress worm: The US government allocated $6.5 million to research the reproduction and release of the Lipdopress worm to devour drug-planted fields in tropical Peru [43].

Jewelry

Insects are used to make earrings, necklaces, tie straps and pins. For example, the wing-cases of gold-enameled weevils hung from necklaces [5,44]. Also, muslin gowns were embroidered with the iridescent green elytra of jewel beetles.

Watch beetles: These beetles are usually displayed as living jewels in the Mexican market [5,44]. Batik: It is an Asian way of dyeing fabric, using beeswax. It is also commonly used across Africa. Scorpion: The poison in scorpions are often used to produce antidotes to scorpion bites. Silkworms: they are used for silk production [44].

Red seed: This can be obtained from small, oval-shaped insects that contain Carminic acid. By extracting aluminum salts and calcium, the reddish pigment which is often used to colour food, dyes and cosmetics can be obtained [39]. Insects can be big business. Insects and insect products are used to pollinate crops, produce medicines, promote and protect agricultural health and to provide nutrients for humans, pets and live animals. They can be also used as tools for conducting research or as works of art [44].

Using Insects for Research Purposes

Insects provide a fundamental tool for studying many aspects of biology**.** *Drosophila melanogaster* for example is a valuable organism for biological research, especially in the fields of genetics and developmental biology because apart from being a common fruit fly, it is small, has a short life cycle, cheap and easy to reproduce [5].

The genome of *Drosophila*, one of the first organisms to be sequenced, maps the gene structure of some model organisms. Gene products such as *Drosophila* polypeptides and transcripts and research tools such as the *Drosophila* Activity Monitor for circadian rhythm research provide excellent products on the market for the science industry [5].

Insect products are also marketed for other research purposes. For example, they are used for genetic and leveraged molecular markers. The enzyme luciferase, derived from fire flies, is an excellent marker for measuring gene expression. These markers are commercially produced and sold. Insect-derived cell lines are another powerful research tool. For example, protein-based human and veterinary vaccines and therapeutic proteins are produced in insect cells using Baculovirus bacterial vector systems [5].

Pharmacology

Even 3,600 years ago, insects, insects' body parts and their venoms were used to treat a number of human ailments. For instance, field cricket Hemolymph has a high concentration of sodium ions and is recommended in drugs for the treatment of bladder and kidney dysfunction. Hemolymph has antibacterial properties and is therefore recommended in prescriptions to treat bacterial infections and putrefaction. Traditional Chinese medicine includes a multitude of insects and other arthropods in its pharmaceuticals [5].

Dried beetles, blistered beetles, silkworm larvae, cicada nymphs and adults, recipes using mole crickets, Mantid oothecae and silk worms can be purchased in traditional Chinese pharmacies.

Honey, royal jelly, bee pollen and propolis are sold to treat all kinds of diseases from anorexia to insomnia, to cardiovascular diseases and wound healing [5,36].

Blister beetles (family, Meloidae) are the main source of Cantharidin, the active ingredient in the Spanish fly. This chemical has been used for topical treatment of warts and small *Molluscum contagiosum* infections and when ingested, exercises its properties. Cantharidin overdose can cause acute kidney failure and death. Chinese researchers have discovered that certain species of blister beetles, which are long used in traditional medicine, have anti-tumor properties. Researchers are trying to balance potential cancer-fighting properties with adverse side effects [5].

An Overview of Insect-Inspired Flying Robots

Insects have attracted the attention of many scientists and engineers because they provide an endless source of inspiration for creating innovative engineering designs. For example, by imitating flying insects, highly efficient biomimetic drones may be manufactured. Secondly, the aero-elastic frame-work of insect flapping has been applied to the design of a nano-enhanced aerial vehicle [45].

Small, Flying Robots

Small, flying robots mimic the flight dynamics of insects and micro-technological hybrids of live insects (cyborgs). The production of a robot with adaptive swimming appendages was inspired by the water beetle [45].

Conclusion

The breeding of insects and the production of insect proteins have become emerging industries. Considering that the technology of producing and breeding insects for the consumption of humans, livestock, and poultry and fish face lots of challenges, agricultural waste can be used to breed insects for use. The fact that insects are beneficial in a lot of aspects suggests that they have the potential to become valuable resources for future establishments like the food industry, pharmaceuticals, etc.

Conflict of Interest

There is no conflict of interest between the authors

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