Editorial Corner

# Insect Biorefinery: Sustainable Application of Insects in Circular Economy

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Over the past decade, the circular economy has become one of the most dominant trends worldwide. Governments are getting a lot of attention on their political agendas owing to the potential of circular economy for sustainable economic growth [1]. In particular, the circular economy paves the way to achieve the United Nations Sustainable Development Goals (SDGs). The key goals that have the significant and direct environmental impacts towards the economic dimension include SDG7 (affordable and clean energy), SDG12 (responsible consumption and production), and SDG8 (decent work and economic growth). In contrast to the linear economy (take-make-use-dispose), the circular economy is a model that aims to convert goods/products that are at the end of their service life into resources/raw materials for other goods/products, closing loops in industrial ecosystems and minimizing waste, i.e. zero waste concept [2], [3]. In this new economic system, waste needs to be converted into biological and technological "nutrients" that can meet the needs of human society.

The key fundamentals of the circular economy are reduction of new inputs and the utilization of natural resources. Minimization of resource loss, selections of green materials, prioritization of the use of renewable and recyclable resources, reduction of greenhouse gas emission, sharing energy consumption, and prolong product shelf life are strategies to meet with the circular economy [4]. Recent studies have shown that the potential of insect biomass in the circular agrifood system is of interest. There are a few reasons to motivate the increased focus on insects in the circular economy. Insects have excellent ability to convert organic matter derived from food waste into protein, therefore they help to reduce food loss. Insect rearing requires less space, less water, and generally less energy consumption than other traditional livestock [5]. Due to rich nutrient profile in insects, food products derived from insects promote a more balanced human meals and animal diets. Additionally, by-products obtained from insect production, such as insect debris, can be used as fertilizer for agriculture activities [6] and as raw material for biocompostie [7]. This enables the reintroduction of insect feeding substrates into the food production chain, in line with the principles of the circular economy and the goal of sustainability.

In the process of scientific and technological progress, human beings often generate many innovative ideas to solve new difficulties or challenges, just like the current trend of insect biorefinery sweeping the world. The idea of insect biorefinery is to use the wide biodiversity of insects and the diversity of their potential diets to develop a series of new technology platforms in line with the concept of sustainable development, which can effectively convert all types of organic matter residues in any given area. Insects, a powerful population evolved from natural environments, are the main primary consumers and decomposers in the food chain. Many species of insects could feed on different kinds of plants, animal waste and even carcasses, and reproduce at an unrivaled rate. At this stage, many new insect biorefineries are exploiting these properties of insects to produce high-value animal feed for the fast-growing livestock and fisheries markets, while having minimal environmental impact (no ocean depletion or deforestation), providing Sustainable agricultural products contribute to systems based on the efficient conversion of local biomass [8]. In doing so, it addresses resource and land supply issues as well as environmental degradation. In addition, insects can be used in applications other than food or feed. The versatile application of insect biorefinery will also make future developments in large-scale production more interesting when biodegradation is the main purpose and food safety concerns are an issue.

An important by-product of current insect biorefining is the insect exoskeleton [4]. The main component of the exoskeleton is chitin, a polysaccharide like cellulose, which is the most abundant compound in the biological world after cellulose. Cellulose is a polymer of glucose, while chitin is composed of glucosamine. Chitin has many industrial applications, such as edible films, dyes, industrial films, biodegradable surgical thread or a binder in paper reinforcement. It also can be potentially applied in the production of self-healing coatings, which are used extensively in the automotive, aerospace, and plumbing industries. A more versatile product from insect biorefinery is chitosan, which is readily produced from chitin by deacetylation. Chitosan contains active amino groups and is soluble in acid solutions with higher molecular weights. Chitosan is a positively charged natural polymer with many advantages such as non-toxicity, biocompatibility and biodegradability. It can be used in many fields, including food processing, agriculture, and biodegradable films and plastics. Chitosan has been extensively studied in biomedical research and development due to its potential antibacterial and antioxidant activities.

Insects can be used both as fodder and as food. Both of these uses make insects legally "livestock"; therefore, all regulations regarding animal feed, feeding, health, welfare and hygiene must apply. Insects are a promising and more sustainable alternative to traditional protein feeds such as plants and fishmeal because they have a low environmental impact and increase organic waste. Even though insect biorefinery still has the problem of cost competitiveness in the market, with the growth of the global population, the reduction of natural resources, the requirements of countries for sustainable development and the advancement of insect industrial farming technology, it is believed that insect biorefinery will be an important part of circular economy soon. The specific purpose of this article is to arouse readers' interest in the link between insect biorefinery and circular economy, and hope that readers understand insect biorefinery and its importance in circular economy.

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