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Promising Direction: Use Of Insects As Raw Material For Chitosan Production

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Abstract
The article examines the possibility of using insects as an alternative source of chitosan. The chemical composition of insect exoskeletons, the main stages of the technological process for obtaining chitosan, and the advantages of this raw material in terms of sustainable development are described. It has been shown that insects can be considered as a promising and environmentally safe raw material base for the production of chitosan. Chitosan is a natural biopolymer with high biological activity and a wide range of practical applications.
Keywords: chitin, chitosan, insects, biopolymers, biotechnology, deacetylation

Introduction

The development of biotechnology and the transition to sustainable development principles are leading to a growing interest in renewable biopolymers.

Chitosan is one of the most promising polysaccharides, obtained by deacetylation of chitin. Due to its physicochemical and biological properties, chitosan is widely used in medicine, pharmaceuticals, the food industry, agriculture, and environmental protection.

The traditional source of chitin is the waste of marine crustaceans processing. However, the seasonality of extraction, high mineral content of raw materials, and potential allergenicity stimulate the search for alternative sources. In this context, insects represent significant scientific and practical interest.

Chitin is a linear nitrogen-containing polysaccharide consisting of N-acetyl-D-glucosamine residues connected by β- (1→4) -glycosidic bonds. Chitosan is formed as a result of partial or complete removal of acetyl groups from the structure of chitin. The exoskeleton of insects contains chitin, proteins, lipids, and relatively small amounts of mineral substances. This fact makes it advantageous to distinguish insects from crustaceans and simplifies the technological process of obtaining chitosan.

The production of chitosan from insects in Uzbekistan has not received significant development to date and is fragmentary. The country lacks a well-established industrial base and stable technological chains in this area, which allows us to consider the production of chitosan as a new and promising direction in the formation stage.

The technology for obtaining chitosan from insects consists of preparation
and degreasing the raw material.
The raw materials are dried and mechanically ground. If necessary, degreasing is carried out using organic solvents or heat treatment, which is especially relevant for insect larvae.

Deproteination. The removal of proteins is carried out by treating the ground raw materials with sodium hydroxide solutions. As a result, protein components pass into the solution, and the chitin retains its structural integrity.

Demineralization. Demineralization is carried out using solutions of mineral acids, most often hydrochloric acid. A low content of mineral salts in insects allows for a reduction in acid concentration and processing time.

Deacetylation. Deacetylation is a key stage of the process and is carried out when treating chitin with concentrated alkaline solutions at elevated temperatures. The resulting chitosan is characterized by a certain degree of deacetylation, which affects its solubility and functional properties.

Using insects as a source of chitosan has several advantages:
1) high growth rate and reproduction rate of insects;
2) the possibility of year-round cultivation;
3) low cost of raw materials and energy;

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4) reduction of the environmental burden;
5). correspondence to the concept of a circular economy.

Chitosan, obtained from insects, is comparable in characteristics to chitosan of traditional origin and can be used in medicine and pharmaceuticals; agrobiotechnology; the food industry; and water and soil treatment systems.

Chitosan is widely used in agriculture - as a biostimulant that increases vegetable yields by 25-40%, as a means of combating soil nematodes in the ground, stem and root rot, rust; as a special coating for fruits that increases their shelf life, as a feed additive that increases the resistance of animals to infectious diseases and enriches the feed.

As well as in biotechnology and ecology - purification of wastewater from protein, oil, fat and other contaminants, immobilization of enzymes, sorption of heavy metals and radionuclides, additive in the production of detergents.

Examples of chitin source insects
Black lioness (Hermetia illucens)
2) Flour worm (Tenebrio molitor)
3). Locusts
4). Locusts
5) Bees

The exoskeleton of bees, like other insects, is formed by a cuticle, which has a complex chemical composition. Main components:

1. Chitin

Polysaccharide (β-1,4-polymer of N-acetylglucosamine).
- It forms a strong framework of the exoskeleton.
- Provides mechanical strength and elasticity.

2. Protein of the cuticle

- Structural proteins (arthropodins, sclerotypes, etc.).
They bind to chitin, forming a chitin-protein complex.
- After the **sclerotization** (tanning) process, they give the exoskeleton hardness and stability.

3. Lipids

- Mainly waxes and fatty acids.
They form the outer layer (epicuticle).
- Prevent water loss and protect from chemical effects.

4. Phenol compounds

- Tyrosine derivatives (e.g., quinones).
They participate in sclerotization, "sewing" proteins and chitin.

5. Mineral substances (in small quantities)

- Calcium, magnesium, zinc, etc.
- Increases the strength of individual sections of the exoskeleton (especially the mandible).

The honeybee's exoskeleton is a chitinous-protein matrix impregnated with lipids and reinforced with phenolic compounds, with minimal mineral impurities.

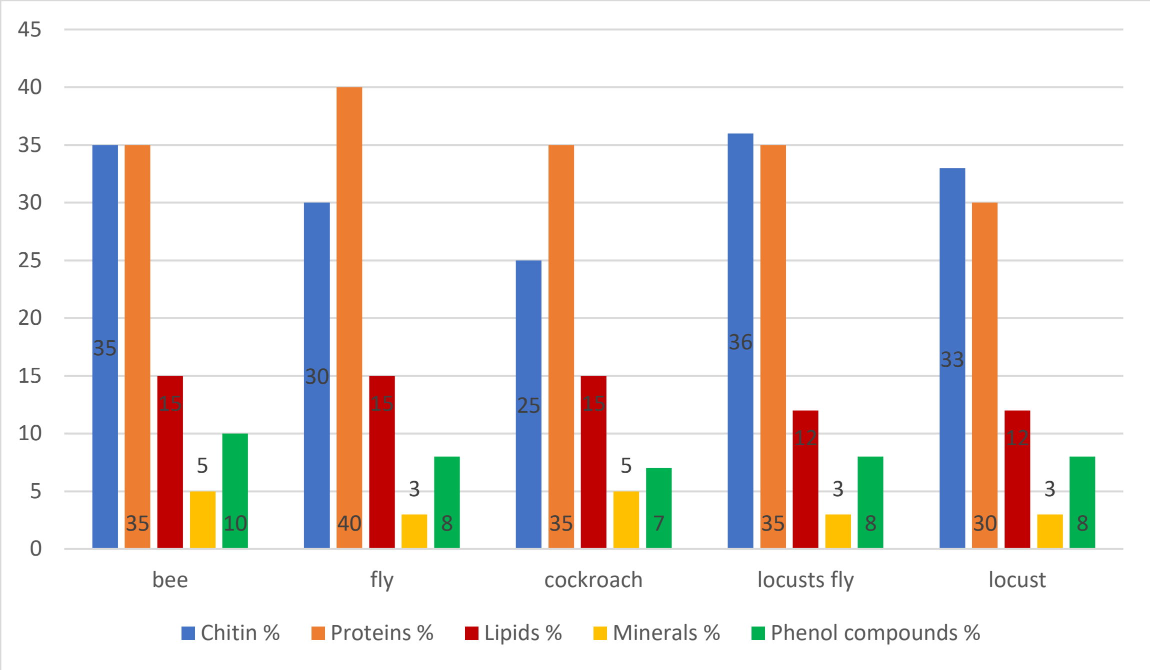

Figure 1. Chemical composition of insect exoskeleton

Stage	Process description	Main reagents / conditions	Result
1. Collection and preparation of raw materials	Collecting insects, separating scales, washing, drying	Water, drying 60-80 °C	Dry chitin-containing raw materials
2. Grinding	Mechanical grinding of the exoskeleton	Crushers, mills	Exoskeleton powder
3. Demineralization	Removal of mineral salts ($CaCO_3$ etc.)	HCl 1-2 M, 20-25 °C	Ash-free raw materials
4. Deproteination	Removal of proteins	NaOH 1-5%, 60-90 °C	Chitin
5. Decolorization (optional)	Removal of pigments	H_2O_2 or ethanol	Chitin clarified
6. Washing and drying	Removal of reagent residues	Water to neutral pH	Pure dry chitin
7. Deacetylation	Conversion of chitin to chitosan	NaOH 40-50%, 90-120 °C	Chitosan
8. Cleaning and classification	Filtration, drying, fractionation	Filters, drying cabinets	Ready chitosan
9. Quality control	Determination of deacetylation degree, MM	IR spectroscopy, titration	Product of specified quality

Table 1. Chitosan production scheme from insects

Conclusion

In conclusion, chitin and chitosan are versatile polymers with various properties that make them economically attractive and useful in many industries, including food, agriculture, wastewater treatment, textile engineering, biomedicine, biotechnology, sanitation, cosmetics, textiles, and the paper industry.

Analysis of modern research shows that insects are a promising alternative source of chitin and chitosan. The development of technologies for their industrial cultivation and processing can ensure sustainable and environmentally safe production of biopolymers. Further research should be aimed at optimizing technological parameters and assessing the economic efficiency of this approach

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