UDK 573.6.086.83:582.284

PROSPECTS OF INDUSTRIAL PRODUCTION OF CHITIN-GLUCAN COMPLEXES FROM FUNGAL CULTURES

DOI: https://doi.org/ 10.15673/fst.v15i4.2259

Article history

Received 14.08.2021
Reviewed 15.09.2021
Revised 12.10.2021
Approved 01.12.2021

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Cite as Vancouver style citation

Siroid O, Klechak I, Duhan O. Prospects of industrial production of chitin-glucan complexes from fungal cultures. 2021;15(4):69-76. DOI: https://doi.org/10.15673/fst.v15i4.2259

Цитування згідно ДСТУ 8302:2015

Siroid O., Klechak I., Duhan O. Prospects of industrial production of chitin-glucan complexes from fungal cultures // Food science and technology. 2021. Vol. 15, Issue 4. P. 69-76. DOI: https://doi.org/10.15673/fst.v15i4.2259

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Abstract. The paper is devoted to the problem of producing chitin-glucan complexes as an alternative to chitin and chitosan. These biopolymers are present in arthropod exoskeletons and other skeletal elements, as well as in fungi and algae cell walls. Chitin-glucan complexes are widely used as sorbents, fillers, and agents for enzyme immobilization in a range of fields including medicine, biotechnology, food industry (particularly in brewing to remove sediment), cosmetology, agriculture, and manufacturing. Due to their fungicidal and antibacterial properties, these biopolymers are used as plant protection products and as biofertilizers. They also have a lot of potential for regenerative medicine and tissue therapy because of their biocompatibility and non-toxicity. The paper considers the main methods for isolation of chitin-glucan complexes and features of commercial production of chitin-[A2] gluconate complexes from fungal cultures, with a focus on the mild alkaline process and the use of an enzymatic treatment to improve production and obtain a product with a stable degree of deacetylation. Also, the paper discusses potential producers and optimal cultivation conditions for obtaining the maximum amount of biomass, which is directly proportional to the amount of biomass produced and is dependent on strain, cultivation, and isolation process conditions. The cost of these polymers largely depends on the cost and availability of raw materials, so chitosan and chitin derived from fungal cultures are more environmentally friendly and relatively inexpensive, owing to their ability to be cultivated in industrial waste, lack of seasonality, and availability of producers.

Key words: chitosan, chitin, chemical properties, production methods, application, commercial production.

Introduction. Formulation of the problem

The research and practical application of biopolymer materials have emerged as a critical study area for macromolecular compounds in recent years. The total annual production of synthetic polymers is about 140×10^6 tons/year. The global industry produces around 140×10^6 tons of synthetic polymers annually; the majority of them are complex and time-consuming to decompose in the natural environment, so the need for biodegradable polymers (such as chitin and chitosan) as alternatives in the modern world is acute[1-3].

After cellulose, chitin is the second most abundant natural polymer. This biopolymer is found in arthropod exoskeletons and other skeletal elements, as well as in the cell walls of fungi, algae, and other living organisms [2,4]. Chitin and chitosan are polysaccharides that exhibit fiber and film formation, as well as sorption and ion exchange properties. They also have a high biological activity, which makes them potentially useful in medicine, biotechnology, food, cosmetics, and other industries [2,3].

World's production of chitin and chitosan increases, which makes it necessary to address the issue of expanding raw materials for these biopolymers every year. Natural amino polysaccharide – chitin are seafood waste, insect covers and cell walls of fungi [1,3].

Chitin was first isolated from the cell wall of champions by Henry Brakonot in 1811 and was naming fungin. From a chemical point of view, this substance was crude chitin. Therefore, the term "chitin" was introduced and established in the scientific literature in 1823 thanks to Henri Odier [1].

Chitosan was first isolating in 1859 by Pierre Rouge. Despite its presence in some species of fungi, the main source of production is chitin, which in the process of deacetylation is converted into chitosan. Active and detailed study for its practical application began only in the 30s of last century [1, 3, 4]. Depending on the source of raw materials, chitin differs in structure and properties [2,1]. Although

chitin and chitosan were obtained on an industrial scale from crustacean shells, the most promising in terms of scale is the isolation of these polymers from fungal cell walls using waste-free technologies and milder production conditions [1,5].

Recent studies of the mechanical properties of branched β-glucan associated with fungal chitin (plasticity, elasticity, hardness, deformability) have shown that the so-called fungal nanomaterials can act as a matrix in nanopaper, providing its native and at the same time strong and rigid nanocomposite architecture [6].

Natural variations in the ratio of chitin to β-glucan and the size of fibrils in fungi can be utilized to create both more fragile, high-tensile strength plastic nanofibre networks and very rigid, elastomeric (rubber-like) networks that exhibit substantial fibril stretching with increasing pressure. Additionally, the mechanical properties of these conditions can be improved by combining extracts from various fungal species.

Therefore, **the purpose** of this paper is to consider and substantiate the prospects for using chitin and chitosan derived from basidiomycetes cell walls to meet the needs of the Ukrainian industry, particularly as plastic alternatives.

To achieve this goal, **the following tasks** were set:

– consider the structure and physicochemical properties of fungal chitin glucan complexes;

– substantiate the prospects for the use of chitin-glucan complexes (CGC) in various industries;

– describe the methods of isolating CGC from fungal cultures;

– justify potential producers and cultivation methods.

Analysis of recent research and publications

General characteristics of chitin and chitin-glycan complexes of higher basidiomycetes

Chitin is a linear polysaccharide consisting of N-acetyl-2-amino-2-deoxy-D-glucopyranose linked by 1–4 glycosidic bonds (Figure 1). Chitin isolated from natural sources usually contains 5–10% of 2-amino-2-deoxy-D-glucose residues [1,3,5].

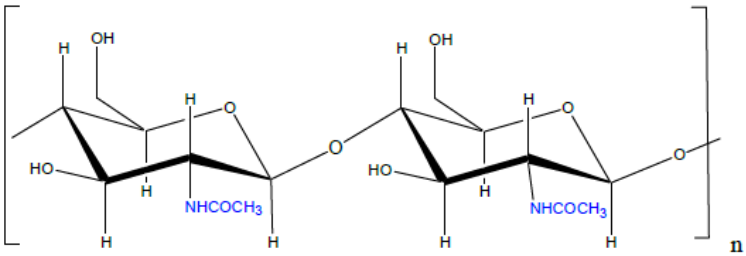

Fig. 1. Structural formula of chitin [3]

Chitin is usually associated with proteins and glucans in organisms. Chitin complexes with glucans and proteins are practically inseparable. The release of salts (including $CaCO_3$) and proteins occurs, respectively, due to the processes of demineralization and deproteinization [3,5,7].

The structure of chitin is similar to cellulose, but differs significantly in chemical properties. It is the presence of intermolecular bonds between hydroxyl's and aminoacyl's groups that provides a low ability to form chelated complexes of chitin and metal ions [5,8].

Chitin exceeds cellulose in terms of mechanical strength and chemical resistance. This is due to its supramolecular structure, the presence of a large number of hydrogen bonds and a smaller active surface [6,9].

Chitin has three polymorphic modifications with different orientations of microfibrils: α, β, γ. A-form is the most common and most stable, it presents in the shell of crustaceans and some mollusks, cuticles of insects, the cell wall of fungi [7]. Chitin is insoluble in water, alkalis, dilute acids, alcohols, other organic solvents, and soluble in concentrated solutions of hydrochloric, sulfuric and formic acid, as well as in some saline solutions when heated, and when it dissolved it noticeably depolymerizes; during deep alkaline hydrolysis glucosamine salts are formed [7,10].

Chitin is able to form complexes with organic substances: cholesterol, proteins, peptides, and also has a high sorption capacity for heavy metals and radionuclides. Chitin does not decompose under the action of mammalian enzymes, but is decomposed by some enzymes of insects, fungi and bacteria responsible for the breakdown of chitin in nature [8]. Chitosan of varying degrees of deacetylation more often used, due to the poor solubility of chitin in the industry.

Chitosan is a linear biopolymer of β-(1-4)-bonded-D-glucosamines (GlcN). Its structure is shown in Figure 2. The molecular weight of chitosan can range from 100 to1500 kDa [7].

The chemical properties of chitosan directly depend on the degree of deacetylation. Due to the binding of a large number of hydrogen ions, the presence of a large number of free amino groups determines the chelating and complexing properties [3,9]. This dependence of solubility on pH allows to obtain chitosan in various forms: capsules, films, membranes, gels, fibers, etc. [10].

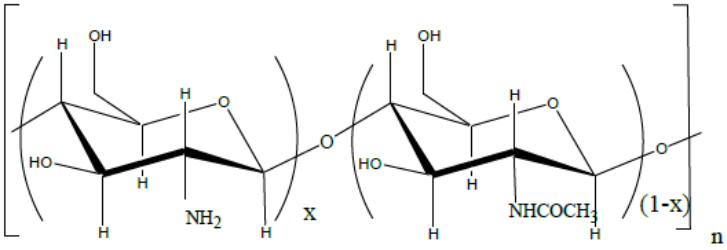

Fig. 2. Structural formula of chitosan [3]

Chitosan is practically a universal sorbent, which ensures its multidisciplinary use, due to its chelating and complexing properties, due as well as the ability to dissolve well in water and organic acids [2,6]. In addition to these properties, the hydrophobic bonds of chitosan and its reticulate structure provide the ability to bind lipid compounds and hydrocarbons. Chitosan derivatives show similar properties [6,11].

Solutions of chitosan in an acidic environment (pH not higher than 6,5) have bactericidal and fungicidal properties [1]. There are data on the correlations between molecular weight, degree of deacetylation and biological activity of this substance [2,3]. For today, scientists put forward two theories about the antimicrobial activity of chitosan. The first concerns low molecular weight chitosan, it can easily penetrate the cell membrane and inhibit cell growth by inhibiting RNA transcription.

The second theory concerns is the ability of chitosan to reduce membrane permeability and leakage of intracellular components through interaction with anionic components of the cell membrane [1,11].

Chitin and chitosan are broken down by bacterial enzymes – chitonases, which provides the possibility of biological utilization of these components [3,12].

Chitin-glucan complexes, like cellulose in plants and chitin in arthropods, are structural components in the cell walls of fungi. In fungal cells, chitin is only in a state of strong binding to proteins, polysaccharides, lipids, trace elements through ionic and hydrogen bonds [4,11]. Physicochemical and biological properties of chitin-glucan complexes depend on the sources and methods of isolation. However, the presence of glucan reduces the thermal stability and strength of films derived from chitin – glucan complexes in comparison with the chitin of crustaceans [3,11,13].

The structural components of the cell walls of fungi include polysaccharides - chitin and glucan, which contain 1-3-glycosidic bonds. Covalent bonds between them make the chitin-glucan complex stable and the impossibility of isolating one of the components without the other [2,3].

The synthesis of chitin begins with glycogen as a starting component and goes through the formation of uridine phosphate-N-acetyl-D-glucosamine with the participation of the enzyme phosphoacetylglucosamine mutase and UDF-acetylglucosamine pyrophosphorylase and subsequently chitin and chitin.

After several successive reactions, the chitin chain begins to increase from the reduced end and is transferred to glucan. The covalent bonds between chitin and glucan, the molecule also contains transverse covalent bonds in micro fibrils, which give strength to the cell wall of fungi [2,6,11]. Some researchers point to the presence of a peptide bridge between chitin and glucan. This structure is characteristic of chitin-glucan complexes isolated from higher fungi. The structure shown in Figure 3 is the most likely.

Chitin and chitosan are widely using in various fields of medicine, cosmetology, agriculture and industry as sorbents, fillers, agents for immobilization of enzymes, semipermeable membranes and others. They are used as plant protection products and as biofertilizers, due to their fungicidal and antibacterial properties [2,6,13].

Because chitin and chitosan are non-toxic and biocompatible, they are of great potential value for regenerative medicine and tissue therapies as wound healing materials, artificial kidney membranes, biological artificial liver, artificial skin, artificial tendons, articular cartilage, drug delivery systems [1,2,7].

The ability of chitosan to absorb is used in brewing to remove sediment. The so-called turbidity in beverages is formed through the components of raw materials and auxiliary materials in the form of proteins, carbohydrates, living cells and oxalates [14,15].

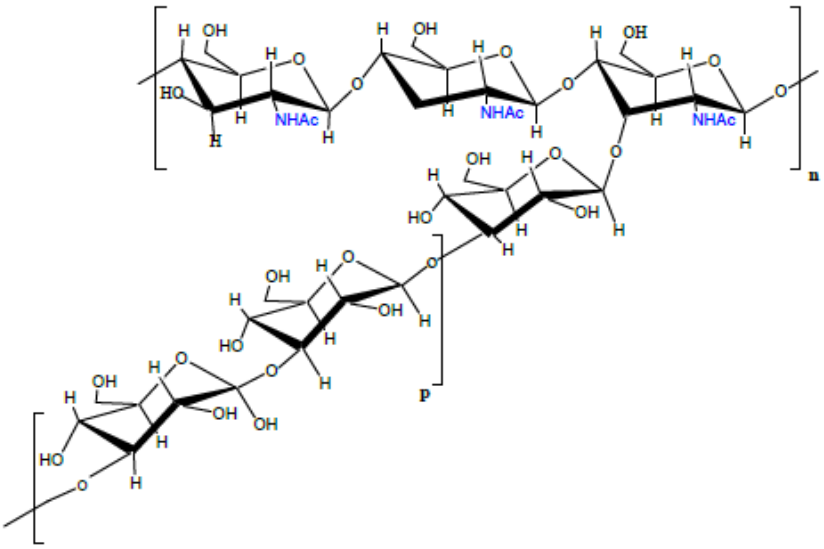

Fig. 3. Chemical structure of chitin - glucan complex of fungi [3]

Possibilities of using chitin - glucan complexes

Chitin is used as an emulsifier of simple and multicomponent emulsions, to stabilize homogeneous and heterogeneous systems in the production of puddings, jellies and to fractionate raw milk [8].

Various physicochemical properties have made chitosan a unique and important polysaccharide with a wide range of applications, especially in the pharmaceutical, biomedical and food industries. Chitosan can be used for targeted delivery of drugs, as well as protein, nucleic acid and virus particles due to the presence of many attachment sites present on the polysaccharide chain [3].

Interest in the production of microbial chitosan was caused by studies by Bartnicki-Garcia and Nickerson, which showed that chitosan is the most common component of the cell wall of the fungus *M. rouxii*. They found that although the fungus exhibits dimorphism, is filamentous and yeast-like forms, chitosan is a major component of cell walls with concentrations of 32.7% and 27.9% of the total cell wall, respectively [13]. This observation gave impetus to the study of the possibility of isolating chitosan from other species of fungi for commercial production, as well as the use of mycelial waste from industrial fungal crops to isolate chitosan.

For today, chitin-glucan complexes derived from fungi have, so far, a limited range of practical applications, compared with chitin and chitosan crustaceans. However, new research opens up more and more opportunities for their application in industry, medicine and agriculture [2,3,11].

Thus, the drug "Mikoton", which is based on chitin-glucan complexes of basidiomycetes, is used as an active supplement. Due to its sorption properties, chitin - glucan complexes are of interest as dietary fiber to improve the activity of the gastrointestinal tract [3,11,16].

For today, wound-healing and antimicrobial properties of chitin-glucan complexes of flour fungi *Vlakeslea trispora* have been established, on the basis of which the drug "Mikoran" was developed, which is used as an anti-burn agent. Acceleration of the wound healing process is associated with stimulation of the proliferation activity of human skin fibroblasts that attach to chitin micro fibrils [6,7,11].

Chitin-glucan complexes of fungi have found their application in agriculture. Thus, based on them, seed processing technologies have been developed in order to increase yields and resistance to bacterial and fungal lesions. Studies of the drug "Mikosan" showed a decrease in the level of bacterial diseases of barley compared to the control [16].

Due to their sorption properties, chitin-glucan complexes can be used as fillers for filters for cleaning liquid and gaseous media from mechanical and biological contaminants [3,11]. Fungal nanoparticles are more acidic than cellulose-based reference filter paper. Conversely, chitin nanoparticles derived from crustaceans *C. pagurus* have an amphoteric surface character.

Due to the ability to film chitin-glucan complexes can be used as matrices for the application of cell cultures.

In the food industry, chitin-glucan complexes can be used as biologically active additives that extend the shelf life of products and, due to the formation of films on the surface, prevent premature spoilage of products [2,3,15].

Features of commercial production of chitin - gluconate complexes from fungal crops

Obtaining chitin and chitosan from mushrooms solves a number of problems related to the reduction of waste, the selection of softer modes of production of components and the reduction of the price of the finished product. Thus, the world production of *Agaricus bisporus* leads to the generation of about 50,000 tons of waste / year, which could be further processed and become a source of chitin-glucan complexes [1].

The cell walls of many species of fungi belonging to the classes *Basidiomycetes,* Deuteromycetes, *Zygomycetes* and *Ascomycetes* contain chitin and can become potential producers of chitin-glucan complexes. Species of fungi: *Absidia coerulea, Absidia blakesleeana, Mucor rouxii, Phycomyces blakesleeanus, Absidia glauca, Trichoderma reesei, Colletotrichum lindemuthianum, Aspergillus niger, Gongronella butleri, Potentius* and chitin and chitosan [4,15].

The amount of chitin in the cell wall of the fungus depends on species-specific conditions, the age of the fungal culture and environmental conditions. The content of chitin in the dry cell wall can vary from 2 to 65% [1,6,11]. In basidiomycetes, the chitin content varies between 50–65% depending on the species [6]. It is very promising to obtain complex fungal products from the wood-destroying fungi *Ganoderma applanatum* and *Phanerochaete sanguinea*. When cultivating these fungi, enzyme complexes are formed that destroy lignin. In industrial production, the culture fluid of these fungi can be used for the "green method" of bleaching cellulose, and fungal bodies can be used as a source of chitin. The claimed content of chitin in these fungi in the range of 10–15% [3,7, 18]. Given the world production of *Agaricus bisporus*, it can be a valuable source for chitin-glucan complexes, as their content varies between 13.3–17.3%, 35%, 20–38% and 43% depending on the age of the culture[1].

Agaricus bisporus have an almost proportional content of chitin and β-glucan, which acts as a matrix in the network of chitin fibers with nanofiber architecture, which provides a very high tensile strength, significantly exceeding the chitin-like nanotubes obtained from chitin. The properties of these nanopapers can be controlled in a controlled way by increasing the content of β-glucan by adding an extract from other types of fungi, which almost completely contain β-glucan [7].

Based on the undeniable prospects for obtaining chitosan from micromycetes, researchers screened several dozen species of yeast and fungi for industrial production of chitosan. Thus, 33 strains of fungi were tested for their ability to produce chitosan.

Research has shown that chitosan can be isolated from all strains, regardless of the class to which they belonged. Some members of the genus *Mucorales* differ in that they contain native chitosan without glucan. The strain of the genus *Mucorales* – *Absidia glauca* - can be considered a promising producer of chitosan, which can be used for commercial production of chitosan.

Other strains that have been identified and can be recommended for commercial chitosan production were *Aspergillus nidulans, Mucor rouxii, Mucor hiemalis, Penicillium digitatum*. It was also concluded that chitosan can be extracted from some common industrial micromycetes, such as *Aspergillus gossypii, Aspergillus niger*, the mycelium of these fungi can be used to produce chitosan [13]. Other strains that have been studied for their ability to produce chitosan are *Rhizopus oryzae, Aspergillus coerulea,* and *Cunninghamella echinulata*.

According to available data, the production of chitin and chitosan correlates with the amount of biomass produced. However, this is also influenced by other environmental factors, culture age and strain-species diversity, so the issue of optimization of these processes remains insufficiently studied [2,3,10].

However, given the growing interest in these products, researchers are trying to maximize the yield of fungal chitin and chitosan, as well as minimize production costs to be able to compete with drugs based on shells of crustaceans and insects.

Based on the mechanism of their biosynthesis in fungal cells, several factors have been proposed that affect the production of chitin and chitosan in deep cultivation. In particular, this is achieved by changing the physico-chemical parameters of the cultivation process and adding additional sources of nutrients to the environment [1,11,19] .

The main factor that determines the cost of production on a commercial scale is the cost of raw materials. In the case of commercial production of fungal chitosan, the main factor determining the cost of production is the raw material used for direct cultivation. Fungal media and cultivation conditions can be modified to produce chitosan with more stable physicochemical properties, as well as chitosan with different physical properties such as molecular weight, molecular size, polydisperse nature, crystallinity and glucosamine content, by changing the composition of the medium and cultivation conditions [1,12,15]. Industrial organic waste, such as molasses from the sugar industry, molasses can be used as an inexpensive source of carbon for growing mushrooms for the production of fungal chitosan [20]

Soybean residues is a nutrient medium for the production of chitosan, the prospects of using food industry waste [16]. Research have shown that the largest amount of chitosan – 4.3 g/kg of substrate, was obtained from *Rhizopus oryzae*, grown on soybean residues.

Apple pomace is another by-product of the food industry that has been studied for suitability for industrial production of the fungal chitosan. Aqueous extract of apple pomace with the addition of nitrogen is a good environment for the development of

microorganisms due to the high content of reducing sugars (60 g/l). The obtained yield of chitosan was 1.19 g per liter of nutrient medium after 72,5 hours of cultivation, which is about 21% of the biomass content [19].

The use of food waste is important for commercial production, as it allows us to maintain a low cost of raw materials needed for production, thereby profoundly affecting the feasibility of biopolymer production.

Another possible medium that can be considered for the production of fungal chitosan is industrial organic effluents. An additional advantage of using organic wastewater as a production medium is that fungi were able to utilize 49% of COD, 51% of total sugar, 43% of reducing sugar, 45% of protein, 61% of total nitrogen and 88% of total phosphorus [17].

It is also necessary to take into account the age of the culture, in particular, the best yield of chitin - glucan was obtained from crops in the late phase of exponential growth [1,10]. Therefore, you to build a process with clearly controlled parameters, minimizing the amount of waste and high quality of the final product, the use of fungal crops as producers of chitin-glucan complexes.

Another important factor that has a significant impact on the biomass of fungi and, in turn, on the production of chitosan, is the method of cultivation of fungi. Fungal biomass can be obtained by both deep and solid phase cultivation.

Solid-phase cultivation is more cost-effective in terms of availability of raw materials, in particular, lignocellulotite waste, ease of process support. However, solid-phase cultivation has a number of disadvantages, in particular, difficulties in controlling the process parameters and additional stages at the stage of isolation.

Deep cultivation allows to control the production process, the possibility of flow cultivation and removal of the finished product, easier isolation of chitin-glucan complexes, however, there is a need for more expensive media for cultivation [16,18,22].

Comparison of chitosan production in solid-phase and deep-sea cultivation showed that the yield of chitosan, using deep-sea cultivation, is lower due to the low accumulation of mycelium thus obtained. Five times more chitosan (6 g/kg substrate) compared to deep cultivation was obtained by solid-phase cultivation with *Lentinus edodes* [23] .

Different strains of fungi have their own requirements to achieve maximum biomass yield and final product yield. Therefore, universal cultivation parameters that could be applied to all fungal strains are not possible, and cultivation parameters must be optimized for each specific strain used to produce chitosan.

Methods of isolation of chitin-glucan complexes. Chitin and chitosan are commercially obtained from crab and shrimp shells. It is removed from crustaceans by acid treatment to dissolve calcium carbonate followed by alkaline extraction to solubilize proteins followed by a decolorization step, which is often added to remove pigment residues and obtain a colorless product. These extraction methods must be adapted to each source of chitin due to the difference in the ultrastructure of the starting materials. The most important derivative of chitin – chitosan, is obtained by partial deacetylation under alkaline conditions [13].

At this stage of production, in the extraction process, in addition to the long duration of the process (up to two days), a large number of highly alkaline and acidic effluents rich in protein waste are formed. The modern chemical approach to the production of chitosan from chitin obtained from crustacean shells limits its use, since the obtained chitosan has a lower level of quality [13,24].

The transition to a biological method of extraction using enzymes or various microorganisms is more efficient and environmentally friendly than chemical methods of extraction. Microorganisms such as *Lactobacillus sp.*, *Bacillus cereus*, *Pseudomonas aeruginosa*, *Bacillus subtilis* and *Bacillus licheniformis* mediate deproteinization and demineralization and can reduce the amount of chemicals required to remove chitosan by reducing the amount of toxic effluents formed.

Biological extraction methods can also be performed using pure enzymes, such as trypsin and alkalase, for deproteinization followed by lactic acid-mediated demineralization.

The degree of deproteinization and demineralization can be from 60% to 95% and from 70% to 95%, respectively, depending on the biological methods used for the stages [25,26] .

In addition to biological methods of deproteinization and demineralization, deacetylation can also be performed using the enzyme deacetylase derived from fungal strains such as *Rhizopus oryzae* or by biotransformation of chitin to chitosan by culturing the fungus in the presence of chitin derived from rape waste.

These methods of chitosan production have little impact on the environment and significantly improve the environmental performance of chitosan production, but the co-cultivation method needs to be further optimized before it can be used on a commercial scale.

The production of chitosan from mushrooms, which does not require stages of demineralization, deproteinization and decolorization, provides an attractive alternative way to obtain chitosan of constant quality. Modern advances in cultivation technology provide alternative methods of organic polymer production. Fungi species such as *Candida albicans, Rhizopus spp., Monilesaurus rouxii, Cunninghamella elegans, Saccharomyces cerevisiae, Gongronella butleri, Phycómyces blakesleeanus,* and *Absidia spp.*, were studied as sources for chitosan production because

they demonstrated a high content of these polymers [13,17,27].

Biotransformation of chitin present in the cell wall into chitosan can be achieved by the enzyme chitin deacetylase present in fungi. The enzyme hydrolyzes N-acetamide groups to N-acetylglucosamine units of chitin and chitosan, thus forming glucosamine units and acetic acid. Chitin deacetylase (EU 3.5.1.4) was first identified and characterized in *Monilesaurus rouxii*, and since then in other species of fungi, bacteria and arthropods.

The enzyme is very stable even at high temperatures and is not inhibited by acetate, a deacetylation product, especially a product synthesized by *Colletotrichum lindemuthianum* and *Aspergillus nidulans.*

The chitosan obtained by the enzyme has a more regular and controlled nature of deacetylation than that obtained after treatment with hot NaOH [28].

This enzyme can be used to transform chitosan from chitin derived from mollusk waste or mycelial waste obtained after the industrial production of products such as citric acid and antibiotics [29]. The use of the enzyme chitin deacetylase will make it possible to abandon the use of hot NaOH used during chemical conversion, thereby significantly reducing the amount of harmful effluents generated during the production of chitosan [30, 31].

Conclusions

Today, chitin and chitosan are gaining more and more practical use in various industries and medicine. Research in recent years reveals more and more useful properties, which accordingly expands the range of their applications. The study of physicochemical and biologically active properties of chitin-glucan complexes allows to optimize the processes of their production.

Fungal chitin is in fact a cheap, renewable alternative to crustacean chitin, with its own nanocomposite architecture of chitin-β-glucan, which contains fungi, which provides additional opportunities to adjust the mechanical and surface properties of the materials obtained from them.

Among the potential producers of chitin-glucan complexes are representatives of the classes *Basidiomycetes, Ascomycetes, Zygomycetes* and *Deuteromycetes*. The amount of chitin and chitosan obtained correlates with the amount of fungus biomass produced and depends on the strain, cultivation conditions and conditions of the isolation process.

Chitin – glucan complex can be extracted from mushrooms by a mild alkaline process, and using the stage of enzymatic treatment, which increases the environmental friendliness of production and obtain a product with a stable degree of deacetylation.

These convenient and manageable characteristics make mushroom-derived materials extremely versatile for a wide range of applications, including coatings, membranes, packaging and paper.

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ПЕРСПЕКТИВИ ПРОМИСЛОВОГО ОТРИМАННЯ ХІТИН-ГЛЮКАНОВИХ КОМПЛЕКСІВ ІЗ ГРИБНИХ КУЛЬТУР

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Анотація. Даний огляд присвячено проблематиці отримання хітин-глюканових комплексів як альтернативи хітину та хітозану. Ці біополімери входять до складу екзоскелету та інших скелетних елементів членистоногих, клітинної стінки грибів і водоростей. Хітин-глюканові комплекси широко використовуються в різних сферах медицини, біотехнології, харчовій промисловості (особливо в пивоварінні для видалення осаду), косметології, сільському господарстві і промисловості у якості сорбентів, наповнювачів, агентів для іммобілізації ферментів. Завдяки своїм фунгіцидним та антибактеріальним властивостям вони використовуються в якості засобів захисту рослин та в якості біодобрив. Завдяки своїй біосумісності та нетоксичності, хітин-глюканові комплекси представляють собою велику потенціальну цінність для регенеративної медицини та тканинної терапії. У роботі розглянуто основні методи виділення хітин-глюканових комплексів і особливості комерційного отримання хітин-глюкатових комплексів з грибних культур, зокрема, екстрагування за допомогою м'якого лужного процесу, та з використанням стадії ферментативної обробки, що дозволяє підвищити екологічність виробництва та отримати продукт зі стабільним ступенем деацетилювання. Також охарактеризовано потенційні продуценти та оптимальні умови культивування, що дозволють отримати максимальну кількість біомаси, яка напряму корелює з кількістю напрацьованої біомаси гриба та залежить від штаму, умов культивування та умов процесу виділення. Собівартість цих біополімерів в значній мірі залежить від вартості і доступності сировини, тому, хітозан і хітин, отримані з грибів є більш екологічними та порівняно дешевими, за рахунок можливості культивування на відходах виробництв, відсутності фактору сезонності процесів та доступності продуцентів.

Ключові слова: хітозан, хітин, хімічні властивості, методи отримання, застосування, комерційне отримання.