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Russulaceae FAMILY MUSHROOMS LECTINS: FUNCTION, PURIFICATION, STRUCTURAL FEATURES AND POSSIBILITIES OF PRACTICAL APPLICATIONS

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The purpose of this paper was to analise the results of own author's research and literature date that concerned lectins of *Russulaceae* family mushrooms, which, despite their widespread, are still poorly investigated. Most studies merely reported about the determination of hemagglutinating activity and the isolation of pure lectin preparations from fresh fruit bodies of this family mushrooms.

This article provides information about lectins physiological role in mushrooms, the list of *Russulaceae* family spesies tested for hemagglutinating activity, as well as procedure of purification, molecular structure and carbohydrate specificity of isolated lectins. Particulary, the most effective methods of lectins purification of the *Russulaceae* family were highlighted.

High lability of the lectins molecules explaned the loss of the activity of these lectins during purification from raw material when standard procedures were applied, as well as the reason why these lectins were not obtained from the dried fruit bodies.

Finally, practical application of lectins of *Russulaceae* family mushrooms in medical-biological researches are described.

Key words: lectins, *Russulaceae*, hemagglutinating activity, carbohydrate specificity.

Lectins are a class of multivalent carbohydrate-binding proteins of non-immune origin, which recognize various carbohydrate-containing structures with a high degree of stereospecificity without catalytic activity [1, 2].

The carbohydrate specificity of sugars and glycoproteins is the cause of selective binding of lectins to certain types of cells and tissues of living organisms [3].

Lectins specificity towards cells (associated with the structure of glycans on their surface) manifests in the ability to agglutinate certain cells, such as erythrocytes belonging to a particular human or animal phenotypes [4], to precipitate glycans and cause various biological effects [5, 6].

Lectins were found in all kingdoms of living organisms: viruses, bacteria, plants, mushrooms and animals [2, 7]. The vast majority of commercially available lectins are obtained from plants, but lectins of true fungi also are of great interest [8, 9]. Their fruiting bodies are able quickly accumulate significant biomass, which can be used for obtaining pure lectins. Our attention was attracted to the lectins of *Russulaceae* family mushrooms, which, despite widespread occurrence of these mushrooms, are poorly investigated at present [10]. On the basis of own research and studies of other authors, this review attempts to explain the reason for this fact and outline the potential for practical application of *Russulaceae* family lectins.

Function

The family *Russulaceae* with two genera — *Lactarius* (the milk-caps) and *Russula* (the brittlegils), has a significant species diversity (there are 750 species of genus *Russula* and 450 species of genus *Lactarius* documented worldwide [11]), and consequently, a large number of potential sources of biologically active substances.

Almost all specimens of this family form mycorrhizal associations with trees and

shrubs, particularly with the main forest tree species (pine, beech, oak, spruce, fir, etc.) [12, 13]. Lectins are involved in the mycorrhizal symbiosis [14].

The physiological role of lectins in fungi is associated with the specific recognition of glycosylated structures at the level of cells, tissues and the whole organism. Lectins in mushrooms participate in the mobilization and transportation of sugars, in the process of forming fruiting bodies (the formation of primordia), in the creation of mycorrhiza and the infection process (penetration of parasitic fungi into the host organism) [15].

The fungal lectins are involved in the recognition of the symbionts during the early stages of mycorrhizae formation. In the *Lactarius deterrimus-spruce* model, the facts that there is a lectin at the surface of the mycelial hyphae and the presence of specific sites for the lectin on the roots hairs are evidence of the involvement of the lectin in the recognition of the host spruce. Thus, the morphologically very similar *L. deterrimus, L. deliciosus* and *L. salmonicolor* are associated with the the spruce *(Picea),* pine *(Pinus),* and the fir *(Abies),* respectively with a remarkable specificity [16].

Detection

Detection of lectins in mushroom extracts is most often carried out using hemagglutination inhibition assay with human and animal erythrocytes, method can be found in reference [2, 17].

A large number of basidiomycetes were screened using the hemagglutination test. Particularly, among the 104 species, collected in Poland, aqueous extracts from *L. rufus* and *L. vellereus* showed high agglutination activity and were among ten the most active. The extract from *R. cyanoxanta* had distinctly higher agglutination activity at 4 °C, than that obtained at room temperature [18].

Agglutinins were well represented by *Lactarius* species among 403 British higher fungi, but fewer by *Russula* species (Table 1) [19]. However, in a study of 110 species of Japanese fungi only *R. emetica*, one of six *Russula* species, did not exhibit hemagglutination. All species that were active against human erythrocytes also agglutinated rabbit red blood cells, except *R. violeipes* that agglutinated only human cells [19–20].

It's interesting that the ability to agglutinate human erythrocytes of all ABO groups had dried mushroom caps of 21 species of the genus *Lactarius* (out of 48 studied), which were stored in herbarium for 8–9 years! The intensity of agglutination reached 1: 64 for the *L. cremor, L. quietus, L. piperatus* extracts, and 1: 32 for the *L. torminosus, L. controversus, L. thejogalus* [21].

Lactarius and *Russula* species of the Ukrainian Carpathians also have hemagglutinating activity toward human erythrocytes. Though the extracts of investigeted fungi did not show group specificity, rabbit, dog and guinea pig erythrocytes showed approximately the same activity. Horse and dog erythrocytes were often more sensitive to *Russulaceae* lectins, while cow and goat erythrocytes frequently showed low sensitivity to these lectins [22, 23].

So, no blood group-specific lectin among *Lactarius* and *Russula* species was found. Only *R. queletii* exhibited specificity to pigeon and horse erythrocytes [18].

We have noticed a significant variability in titers of hemagglutination, depending on the age of fruiting bodies, weather and temperature conditions, even within one mycelium (measurements were performed on mycelia of *L. torminosus* and *L. pergamenus*). Activity may differ more than in 250 times! Although clear correlation between the age of mushroom and the titer of hemagglutination was not found, in general, younger mushrooms had higher hemagglutinating activity than older ones [22, 24]. Evidently, it is much easier to detect lectins in extracts at the moment of their highest activity. According to our observations, higher activity of lectins correlates with their higher content.

Other researchers, in particular [18, 19] came to the same conclusion that caps of young carpophores are usually richer in lectins.

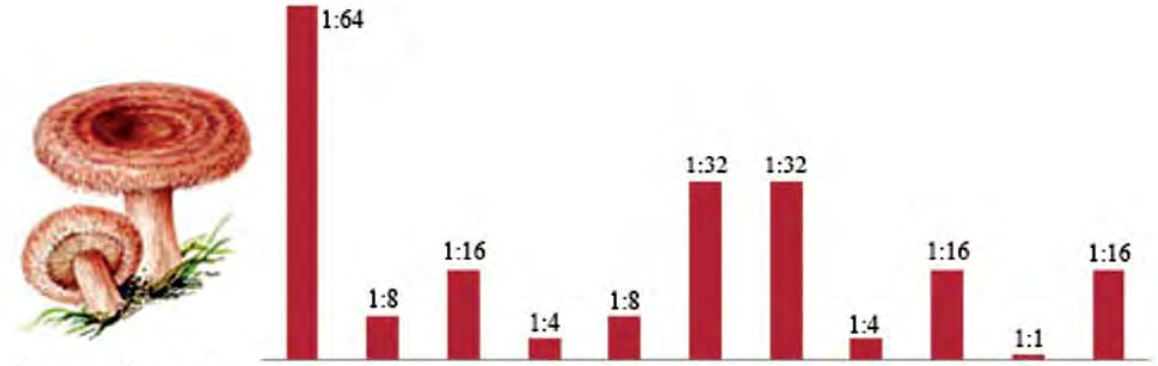
Purification

Lectins are proteins or glycoproteins that consist of one or more polypeptide chains. Procedures that are customary for purification other proteins (precipitation with salts, ion-exchange, affinity and gel chromatography, preparative electrophoresis, etc.) can be used to purified them [1, 2]. However, unlike lectins of other basidiomycota mushrooms, they have certain features. This is due to the high sensitivity of *Russolaceae* family lectins to pH changes, salt precipitation and organic solvents, drying and freezing of raw materials. At the same time, these lectins, can usually withstand heating to 65÷70 °C [22, 23]. This should be taken into consideration when purifying them.

Table 1. **List of Russulaceae family spesies tested for hemagglutinating activity**

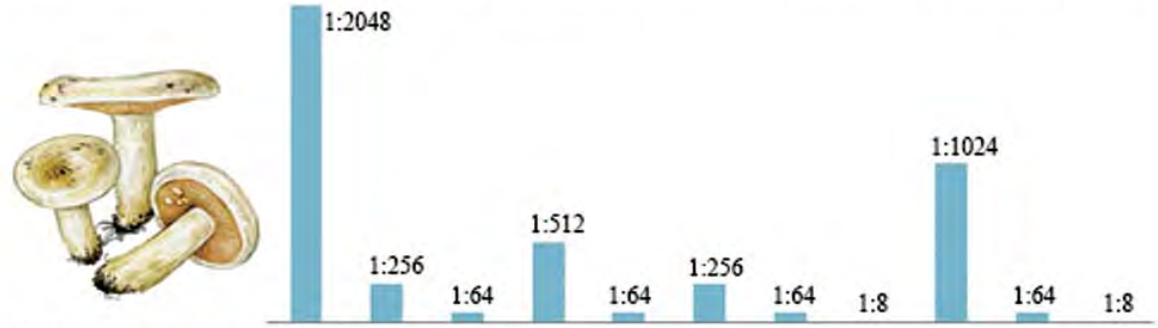
No	***Lactarius* DC. ex S. F. Gray:**	**References**	No	***Russula* (Fr.) S. F. Gray:**	**References**
1	*L. aurantiacus* Fr.	[21]	1	*R. adusta* (Pers.) Fr. **	[19]
2	*L. blennius* (Fr.) Fr.	[21,19]	2	*R. aeruginea* Lindblad	[19, 23]
3	*L. controversus* (Fr.) Fr.	[21,19]	3	*R. alpina* (A. Blytt) F. H. Møller & Jul. Schäff **	[19]
4	*L. cremor* Fr.	[21]	4	*R. atropurpurea* (Krombh.) Britzelm.	[19, 23]
5	*L. decipiens* Quel.	[21]	5	*R. carminea* (J. Schaeff.) Kühner & Romagn.	[19]
6	*L. deliciosus* (L.) Gray	[18, 21, 25, 19, 22]	6	*R. claroflava* Grove	[19]
7	*L. deterrimus* Gröger	[26,19]	7	*R. cyanoxantha* (Jul. Schäff.) Fr.	[19, 23]
8	*L. flavidulus* S. Imai	[27]	8	*R. delica* Fr.	[32]
9	*L. fluens* Boud.	[19]	9	*R. emetica* (Schaeff.: Fr.) S.F. Gray*	[18]
10	*L. glaucescens* Cossl.	[19]	10	*R. farinipes* Romell.	[19]
11	*L. glyciosmus* Fr.	[21]	11	*R. flavida* Frost &Peck apud Peck	[20]
12	*L. helvus* Fr.	[21]	12	*R. foetens* (Fr.) Fr.	[23]
13	*L. laeticolor* (Imai) Imaz.	[20]	13	*R. grisea* (Pers. ex Secr.) Fr.	[19, 23]
14	*L. lignyotus* Fr.	[28,21]	14	*R. illota* Romagn.	[19]
15	*L. necator* (Bull. ex Fr.) Karst.	[22]	15	*R. laurocerasi* Melzer	[19, 20]
16	*L. pergamenus* (Fr.) Fr.	[21, 22, 24]	16	*R. lepida*	[33]
17	*L. piperatus* (Scop.) Gray	[21, 19, 29, 22]	17	*R. nigricans* (Bull. ex Merat) Fr.	[19, 23]
18	*L. porninsis* Roll.	[21]	18	*R. paludosa* Britzelm.	[19]
19	*L. pubescens* Fr.	[21]	19	*R. queletii* Fr.	[18, 19]
20	*L. quietus* (Fr.)	[21, 19, 20, 22]	20	*R. rosacea* (Pers.) S. F. Gray	[20]
21	*L. rufus* (Scop.) Fr.	[18, 19, 30, 22]	21	*R. sardonia* Fr.em Romagn. ***	[19]
22	*L. ruginosus* Romagn.	[19]	22	*R. subfoetens* Smith	[19]
23	*L. salmonicolor* R. Heim & Leclair	[21, 31]	23	*R. vesca* Fr.	[19]
24	*L. sanguifluus* Paul ex Fr.	[21]	24	*R. violeipes* Quel.	[20]
25	*L. serifluus* DC.ex Fr.	[21]			
26	*L. subvellereus* Peck	[20]			
27	*L. subzonarius* Hongo	[20]			
28	*L. tabidus* Fr.	[19]			
29	*L. thejogalus* (Bull.) Fr.	[21]			
30	*L. torminosus* (Schaeff.) Gray	[21, 19, 30, 22]			
31	*L. turpis* (Weinm.)**	[19]			
32	*L. vellereus* (Fr.) Fr.	[18, 21, 19, 22]			
33	*L. vietus* (Fr.) Fr.	[19]			
34	*L. volemus* (Fr.) Fr.	[19, 22]			
35	*L. zonarioides* K hner & Romagn	[21]			

* Hemagglutination only with trypsin treated erythrocytes
** Hemagglutination only with bromelin treated erythrocytes
*** Hemagglutination with neuraminidase treated erythrocytes



L. torminosus, №

	1	2	3	4	5	6	7	8	9	10	11
Mushroom weight, g	11	17	19	25	35	35	37	41	43	43	80
Cap diameter, cm	4.5	5.8	6.5	8	8	10	8.8	9	9.2	12	15



L. pergamenus, №

	1	2	3	4	5	6	7	8	9	10	11
Mushroom weight, g	22	27	37	52	52	88	94	103	143	144	378
Cap diameter, cm	8	10	12	12	13	13	13	15	16	18	28

The titres of haemagglutination in sap from *L. torminosus* and *L. pergamenus* within one mycelium

Although many *Russulaceae* family species showed agglutination activity there are only several publications on obtained lectins (Table 2).

Not always the hemagglutinating activity of *Russulaceae* lectins is remained entirely by the precipitation of lectins with ammonium sulfate and ethanol, which are most often used in the purification of protein molecules [22, 23].

It should be noted that all authors purified lectins only from raw materials harvested fresh. None of the cited studies didn't explain why these lectins were not obtained from dried fruit bodies. In own research [22, 23], it has been shown that the hemagglutination activity strongly reduces or completely disappears after drying, as well as freezing of most species of this family mushrooms.

The reason for this, in our opinion, is the loss of activity of these lectins during purification from raw material using standard procedures.

Affinity chromatography is the most effective method for the purification of the lectins. The affinity sorbents used for their isolation were: stromas of erythrocytes embedded in polyacrylamide gel [25, 26, 31], copolymer of polyvinyl alcohol with a blood group specific substance [30, 34, 29, 24], fetuin immobilized on Sepharose [28]. The purification of other lectins (*L. flavidulus, R. delica, R. foetens, R. lepida*) [27, 32, 23, 33] was carried out by a combination of ion-exchange chromatography and gel filtration. However, in our opinion, these methods are more labour-intensive and less productive than affinity chromatography.

Lectins were eluted from affinity sorbents either with 0.1 M borate buffer (pH 9.0) [28] or heated to +65 °C 1 M NaCl. Specific carbohydrate was not used to remove the lectin from a column due to the absence of interaction of these lectins with monosaccharides and low-cost di- and oligosaccharides.

The elution of lectins by acidic buffer is not recommended because it can cause loss of

Table 2. **List of isolated lectins of *Russulaceae* family species**

Species	Isolation	Structural Properties	Sugar Specificity	References
L. lignyotus 	By affinity chromatography on Sepharose 4B containing immobilized fetuin	98 kDa, Tetrameric with 22 kDa subunits	Desialyzed fetuin, desialyzed glycoprotein from edible bird's nest and desialyzed mucin from porcine submaxillary glands	[28]
*L. deliciosus** 	By a combination of affinity chromatography on stromas of group O erythrocytes embedded in polyacrylamide gel and hydroxylapatite and gel filtration chromatography * Isolated from the carpophores, lectins are also expressed at the surface of the hyphae	37 kDa, Dimeric with two types of subunits (about 19,000 and 18,000)	All the lectins are most specific for DGalβ1-3DGlcNAc residues (TF antigen)	[25]
*L. deterrimus** 		37 kDa, Dimeric		[26]
*L. salmonicolor** 		39 kDa, Dimeric		[31]
L. rufus 	By affinity chromatography on copolymer of polyvinyl alcohol with a blood group B specific substance	98 kDa, Hecameric with 17 ± 1 kDa subunits	Group-specific substances from human blood erythrocytes, asialo-BSM, asialo-ovomucoid, human and bovine thyroglobulins, orosomucoid, fetuin, transferrin, human Ig G, α-phenyl N-acetyl-D-glucosaminopyranoside, 4-nitrophenyl-β-D-galactopyranoside	[30]
L. torminosus 		98 kDa, Hecameric with 17 ± 1 kDa subunits	Fetuin, asialo-BSM, BSM, group-specific substances from human blood erythrocytes, human Ig G, transferrin	[34]
L. piperatus 		97±3 kDa	Group-specific substances from human blood erythrocytes, human Ig G	[29]
L. pergamenus 	By a combination of ethanol precipitation, affinity chromatography on copolymer of polyvinyl alcohol and human blood B group specific substance, and ion exchange chromatography on DEAE-Toyopearl	96 kDa, Hecameric with 16 kDa subunits	The lectin weakly interacts with DGalNAc, while DGalβ1-3DGalNAc and DGalβ1-3DGlcNAc are the most probable candidates for ligands, with which the lectin interacts at disaccharides level. Among them fetuin of fetal calf serum and group-specific substances A, B, and H of human blood were the strongest	[24]

Table 2. Continued

Species	Isolation	Structural Properties	Sugar Specificity	References
L. flavidulus 	The chromatographic procedure utilized comprised anion-exchange chromatography on DEAE-cellulose, cation-exchange chromatography on CM-cellulose, anion-exchange chromatography on SP-Sepharose and gel filtration by fast protein liquid chromatography on Superdex 75	29.8 kDa, Dimeric	Lactose, *p*-nitrophenyl α-D-glucopyranoside, *p*-nitrophenyl β-D-glucopyranoside, inositol and inulin	[27]
R. delica 	It was adsorbed on both SP-Sepharose and Q-Sepharose and unadsorbed on DEAE-cellulose	60 kDa, Dimeric with 30 kDa subunits	Inulin and *o*-nitrophenyl-β-D-galactopyranoside	[32]
R. foetens 	By ion exchange chromatography on CM-cellulose	Not done	Asialo-ovomucoid	[23]
R. lepida 	The purification scheme involved $(NH_4)_2SO_4$ precipitation, ion exchange chromatography on DEAE-cellulose and SP-Sepharose, and fast protein liquid chromatography-gel filtration on Superdex 75	32 kDa, Dimeric with 16 kDa subunits	Inulin and *o*-nitrophenyl-β-D-galactopyranoside	[33]

their activity. In particular, as our studies have shown [22, 23], *Russulaceae* lectins are quite enough stable at high temperatures, but are very sensitive to changes in pH: even a short-term reduction of pH to 4.5 often leads to a loss of 50–75% of hemagglutinating activity, and at pH 3.5 activity of many (but not all) species was completely lost. That's why the elution of almost all *Lactarius* lectins from the affinity column was carried out using 1 M NaCl solution heated to +65 °C. An attempt to eluate the *L. deterrimus* lectin by 0.1 M solution of N-acetyl-D-galactosamine, although was successful [26], did not allow the authors to obtain the expected activity of lectin. In their opinion it was due to incomplete unbounding of this carbohydrate from the lectin by dialysis.

The yield of lectins from fresh mushroom biomass varied from ≈3 mg/kg in *L. pergamenus* [24], 6.4 mg/kg in *L. deterrimus* [26] to ≈ 30 mg/kg in *L. deliciosus* [25].

Molecular structure

There is a small amount of data in the literature concerning the deep learning on molecular structure of lectins of the *Russulaceae* family mushrooms. In particular, there is no data on the crystallographic structure of lectins from mushrooms of this family in complex with a specific carbohydrate inhibitor.

According to the literature (Table 2), purified lectins consist of two (*L. deterrimus, L. salmonicolor, L. flavidulus, R. delica* and *R. lepida*) or four identical subunits (*L. lignyotus*), *L. deliciosus* lectin is also dimer, but has non-identical subunits, with a molecular weight of 18 and 19 kDa.

Except the *L. lignyotus* lectin, whose subunits are bound by disulfide bridges, other studied lectins of the *Russulaceae* family have subunits bound noncovalently.

According to our research, *L. rufus* and *L. torminosus* lectins consist of six subunits with a molecular weight of about 17 kDa,

and *L. pergamenus* — about 16 kDa. It was determined that the linkage between the individual subunits is very labile and the lectin molecule can easily disintegrate, possibly gradually, which is accompanied by loss of haemagglutinating activity. Herewith the hexamer possesses the highest specific haemagglutinating activity. Disintegration of the lectin molecule is taking place under the action of minor pH changes and even under the action of such soft factors as freezing or precipitation of the lectin-containing fraction of proteins with ammonium sulfate, not to mention about drying of mushrooms at +52 ± 2 °C [22, 23]. It should be noted that hexameric structure of a molecule is the phenomenon quite rare in lectins; not more than ten such molecules are described, the most famous is a lectin from an edible snail (*Helix pomatia*) [1, 2].

The data obtained by us explain the decrease of haemagglutinating activity by changes in the molecular structure of fungal lectins of the *Russulaceae* family, observed during drying and storage of the fruit bodies and throughout the purification of lectins. The disappearance of the hemagglutinating activity is due to the high lability of the quaternary structure of the lectin molecule; this fact probably also explains a small number of studies on lectins of a given family. However, lectins of the genus *Lactarius*, as compared with lectins of the genus *Russula*, are generally more resistant to such impacts, particularly towards drying, and therefore more promising for further research.

Carbohydrate specificity

The most important functional characteristic of lectins is their specificity to carbohydrates, which often determines the opportunities for their further use.

The literature suggests that *Russulaceae* family lectins rarely exhibit specificity to monosaccharides, and much more often to complex oligosaccharide structures, at least to disaccharides. Mostly such disaccharide is DGalβ1-3DGalNAc (TF antigen) [25, 22, 23].

The hemagglutinating activity of *L. flavidulus* lectin was inhibited by a variety of simple sugars, in particular lactose, *p*-nitrophenyl α-D- and β-D-glucopyranosides, inositol, and by the polysaccharide inulin [27]. The *L. deterrimus, L. deliciosus* and *L. salmonicolor* lectins have almost identical molecular mass and the same affinity for DGalβ1-3DGalNAc, a disaccharide which contains D-galactose and N-acetyl-D-galactosamine [25, 26, 31]. The same can be said of the *L. torminosus, L. rufus* and *L. pergamenus* lectins, the best sugars to interact with were complex oligosaccharides with minimal active disaccharide chains of DGalβ1-3DGlcNAc or DGalβ1-3DGalNAc. The best inhibitors of their activity were group-specific blood components human (ovariomucin) and human immunoglobulin G [34, 30, 24].

In case of *L. lignyotus* lectin the most effective inhibitors of its agglutinating activity were desialized fetuin, desialized glycoprotein from edible bird's nest and desialyzed mucin from porcine submaxillary glands [28].

Inhibitors of agglutinating activity of *R. delica* and *R. lepida* lectins were inulin and *o*-nitrophenyl-β-D galactopyranoside [32, 33].

Practical application

The selectivity of lectins to carbohydrate structures makes them very important tools for biochemical studying of glycoconjugates of the membrane and cell wall [35]. Thereby, due to the high specificity of binding of lectins to membrane carbohydrate structures, they have become extremely useful for the identification and differentiation of closely related species or strains of single-celled parasitic organisms. In particular, *L. controversus* and *R. nigricans* lectins characterized the variety of sugar structures of the cell walls of 114 pathogenic strains of the *Candida* genus. The lectin from *L. deliciosus* was used in researching the biology and taxonomy of the fungal organisms from the class of *Chytridiomycetes* inhabiting the alimentary canal in ruminants. *L. torminosus* lectin was used in researching glycoconjugates taking part in the identification reactions of embryonic cells in the urogenital morphogenesis in bird embryos [15].

Lectins from *R. delica* and *R. lepida* potently inhibited proliferation of HepG2 hepatoma and MCF 7 breast cancer cells [32, 33]. The lectin from *L. flavidulus* suppressed the proliferation of HepG2 hepatoma and L1210 leukemic cells [27]. Both above mentioned lectins from *L. flavidulus* and *R. delica* inhibited the activity of human immunodeficiency virus type 1 (HIV-1) reverse transcriptase [27, 32].

The lectin of *L. deliciosus,* which is specific to DGalβ1-3DGalNAc, can be used to follow the expression the tumor-associated Thomsen-Friedenreich (TF) antigen [36].

The purified by us lectins from *L. torminosus* and *L. pergamenus* may find application as the histochemical reagents for the comparative histochemical investigation of kidneys of the newborn and adult rats [37, 38].

The key role of lectins in the formation of mycorrhiza between certain conifer tree species and *Russulaceae* family mushroom species has been proved.

The most effective method for the purification of lectins from the *Russulaceae* is affinity chromatography using sorbents with DGalβ1-3DGlcNAc structures (immobilized fetuin, blood group-specific substances). In the purification process should be taken into account high sensitivity of *Russulaceae* lectins to changes in pH and precipitation with ammonium sulfate and ethanol, their relatively thermal stability (up to + 70 °C).

The reason for the relative instability of the lectins of the *Russulaceae* family, in our opinion, is the features of the molecular structure. The molecules of these lectins consist of 2, 4 or 6 subunits, and the linkage between the individual subunits is very labile and the molecule of lectins can easily disintegrate (possibly gradually), which goes hand in hand with the loss of haemagglutinating activity.

Lectins isolated from widespread *Russulaceae* family mushrooms can find practical applications for the research of mycorrhizal symbiosis, as histochemical reagents in the detection of carbohydrate structures (for example, TF antigen), for the study of the topography of membranes and glycoconjugates of cell walls of various biological objects.

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ЛЕКТИНИ ГРИБІВ РОДИНИ *Russulaceae*: ФУНКЦІЇ, ОЧИЩЕННЯ, СТРУКТУРНІ ОСОБЛИВОСТІ ТА МОЖЛИВОСТІ ПРАКТИЧНОГО ЗАСТОСУВАННЯ

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Метою роботи є опис результатів власних досліджень та досліджень інших авторів, що стосуються лектинів грибів родини *Russulaceae*, які, незважаючи на велике поширення, на сьогодні недостатньо досліджені. Більшість робіт повідомляє лише про визначення гемаглютинувальної активності та виділення лектинових препаратів зі свіжих плодових тіл грибів даної родини.

У статті наведено інформацію про фізіологічну роль лектинів у грибах, перелік видів грибів родини *Russulaceae*, протестованих на гемаглютинувальну активність, а також процедуру очищення, структуру молекули та вуглеводну специфічність виділених лектинів. Розглянуто найбільш ефективні методи очищення лектинів родини *Russulaceae*.

Висока лабільність молекули пояснює втрату активності цих лектинів під час очищення із сировини з використанням стандартних процедур, а також неможливість їх отримання із сушених плодових тіл. Також описано практичне застосування лектинів грибів родини *Russulaceae* в медико-біологічних дослідженнях.

Ключові слова: лектини, *Russulaceae*, гемаглютинувальна активність, вуглеводна специфічність.

ЛЕКТИНЫ ГРИБОВ СЕМЕЙСТВА *Russulaceae*: ФУНКЦИИ, ОЧИСТКА, СТРУКТУРНЫЕ ОСОБЕННОСТИ И ВОЗМОЖНОСТИ ПРАКТИЧЕСКОГО ПРИМЕНЕНИЯ

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Целью работы является описание результатов собственных исследований и исследований других авторов, касающихся лектинов грибов семейства *Russulaceae*, которые, несмотря на широкое распространение, сегодня недостаточно исследованы. Большинство работ сообщает лишь об определении гемагглютинирующей активности и выделении лектиновых препаратов из сырых плодовых тел грибов данного семейства.

В статье приведена информация о физиологической роли лектинов в грибах, перечень видов грибов семьи *Russulaceae*, протестированных на гемагглютинирующую активность, а также о процедуре очистки, структура молекулы и углеводной специфичности выделенных лектинов. Рассмотрены наиболее эффективные методы очистки лектинов семейства *Russulaceae*.

Высокая лабильность молекулы объясняет потерю активности этих лектинов при очистке из сырья с использованием стандартных процедур, а также невозможность их получения из сушеных плодовых тел. Также описано практическое применения лектинов грибов семейства *Russulaceae* в медико-биологических исследованиях.

Ключевые слова: лектины, *Russulaceae*, гемагглютинирующая активность, углеводная специфичность .

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