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Prospects for use of beans lectins to obtain biopreparations for agriculture

One of the priority tasks of biotechnology is supplying agricultural farming with cheap, environmentally clean and effective phytopreparations based on biologically active plant substances, and particularly lectins that are widely used in agriculture, medicine, pharmacology and other branches of industry. The data on the study of protein complex, activities of nutritional as anti-nutritional components of common bean and the development of advanced technologies for agricultural biopreparations on the basis of common bean lectins by biotechnology techniques are highlighted in this review.
Keywords: common bean, protein components, lectins, biopreparations, calli.

The President of Kazakhstan Nursultan A. Nazarbaev pointed: «Production efficiency and product quality improvement will depend on the development and use of applied agricultural research on the adaptation of existing technologies and the transfer of new technologies to producers» on the Republic Forum of agricultural workers [1].

An important way to solve the food problem is the ecologization of agriculture using biological agents for plant protection from pests, weeds and diseases, as well as the application of biological products to increase the productivity of crops. The main purpose of biological preparations is to reduce and avoid the use of harmful chemical substances in industry, and agriculture, and to promote transition to resource-saving, pollution-free and safe technologies.

However, use and application of biological methods in our country currently are not sufficiently developed. Basic issues of decreasing yields and quality of crops are low capacity of the soil, the high price and low efficiency of fertilizers, the negative impact of pesticides on plants and soil biota [2].

About 9.000 hectares of agricultural fields in Kazakhstan are currently infested by pests, more than 2.5 million hectares by weeds. Around 70 diseases of microbial origin are spread. The following situation is actual for plant protection products in Kazakhstan: registered pesticides – 370 types, including biopesticides – 7 types (1.9%); the world production of biological products – about 100 types, in Kazakhstan – 2 types (2%); the annual import of pesticides on average – 11-18 thousand tons, pesticides used in 2008 – 23.7 thousand tons, including import – 21.2 thousand tons (89.5%), domestic – 2.5 thousand tons (10.5%) [3].

The Republic of Kazakhstan has a large market potential for the effective application of biological products – sectors of oil and gas industry, agriculture, livestock production and others.

Marketing research shows that the current annual demand of the domestic market of the Republic of Kazakhstan, for example, in biological products for the agroindustrial complex is 8300 thousand tons; for oil and gas sector – more than 700 tons; for the environmental protection – more than 500 tons. However, for the present moment there is no established production of biological products in the Republic, and present issues are partially addressed by importing biological and chemical agents from abroad.

A range of microbiological preparations for the needs of industry, agriculture, animal husbandry and environmental protection are currently established and successfully applied. At the same time, development of biological products of plant origin is not enough. The use of herbal medicines in combination with modern farming techniques will make full use of the potential of not only land, but also the biological potential of the plants themselves.

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Development of biotechnology in Kazakhstan will restore soil fertility and increase crop yield by 20-30%. The use of wide range protein components of plants opens the great prospects for the development of biotechnology. Currently, an important area of modern biotechnology is occupied by the development of technology for biologically active substances, lectins, in particular, which are widely used in medicine, pharmacology, biology, and other fields of industry. Legume lectins might be of the most importance, as objects of interaction of higher plants and microorganisms. Their structure, location in the plant and plant cell organoids are studied [4].

Chemical and biotechnology worldwide companies, specializing on production of biological products, offer a long list of lectins, labeled lectins, inhibitors and their derivatives, necessary for the production of preparations for plant protection, as well as drugs and diagnosticums. Fundamental studies of the properties of lectins and their use for biotechnological products of new generation are held in many European countries, Japan, USA, China, Russia, Ukraine and Belarus. Lectins are used in laboratory practice for the diagnosis of certain hereditary diseases, identification of some microorganisms. This in itself makes them highly demanded. Besides that, lectins are used in biotechnology as specific reagents that are selectively sorbite certain complex substances: glycoproteins, hormones, sialoproteids, etc. Thus, with lectin,s preparations can be isolated valuable substances, using in the treatment of many serious diseases. A new generation of drugs – a hybrid of lectins and antibodies, to affect organs and tissues seems to be promising as well.

Therefore, mobilization and analysis of domestic plant resources, including promising accessions of beans from Kazakhstan, in order to identify new sources of nutrients and anti-nutritional protein components to study their effects on different cell models and further biotechnological processing are of great theoretical and practical interest in Kazakhstan at the present moment.

To develop the technology of purified common bean lectins the study on the identification of perspective common bean specimens of Kazakhstan and foreign breeding by their amino acid composition is carried out together with investigation on the dynamics of protein accumulation with active lectins factions in different plant parts as further elaboration of recommendations to the isolation and biotechnological approaches for the purification of phytopreparations. Solution for these issues would generate further knowledge on common bean biochemistry to promote subsequent growth of agricultural production and its profitability.

Lectins are common to all organisms, so the study of their functions has a general biological significance. Depending on the source of isolation it is possible to distinguish bactolectins, mycolectins, phytolectins and zoolectins. Lectins are part of the tissues structure, participating in the regulation and protection of the body from external stress factors. Isolated from different organisms lectins are widely used as reagents in biochemistry, histochemistry, diagnosis of certain diseases. In recent years, attempts are also made to use lectins as drugs. Everything said about lectins attract researchers, working in different areas of biology, particularly in biochemistry, cytology, microbiology, plant physiology, biotechnology and pharmacy [5]. The study of lectin activity was conducted among representatives of gymnosperms, monocots and dicots [6], as well as in the aerial shoots of over 2.000 plant species [7].

About 800 species of plants contain lectins. Especially large number is in the seeds of legumes. Synthesis and isolation of phytolectins is less expensive and easier than that of animal lectins, the selectivity of binding to carbohydrate determinants is also very high, which allows their use in diagnostics, and as therapeutic preparations. Quantity of lectins may vary widely, and their activity depends on the biological and physical effects of the environment [8, 9]. Variability in the level of lectin activity in the organs of beans (Phaseolus L.), depends on the phase of development, which is associated with the functional activity of hemagglutinating proteins [10].

At present time a detailed study the physicochemical and biological properties of many phytolectins was done [11, 12, 13], however, their physiological role is still hypothetical, although critical in carrying out the functions associated with the presence of carbohydrate domains, through which specific lectins can interact both with the free mono-and oligosaccharides, and the remnants of carbohydrates consisting of polysaccharides, glycolipids and glycoproteins [14, 15]. Many facts suggests that lectins serve as powerful biological stimulators, activating defence forces of organism, but very little work was done on isolating lectins from plants with high nutritional value. As researches of A.A. Yamaleeva have shown [7], the functions of plant lectins are extremely diverse. Lectins participate in intercellular interactions, the transport of hormones, proteins and RNA, as well as affect cell division, growth and differentiation.

Lectins can be valuable as biochemical reagents, with the increasing use in the experimental cytochemistry, diagnosis of certain diseases and in biotechnological processes of complex carbohydrates containing substances. Lectins can serve as mediators between nitrogen fixing bacteria and the host plant, particularly in the functioning of the symbioses [16]. Transgenic plants showed a protective role of lectins from insects and pests [17, 18, 19].

In addition to participating in the defensive reactions to insects, pests and phytopathogenic fungi lectins are involved in the formation of responses to abiotic stress factors. Immersed data on increased activity of plant lectins in the temperature and salt stress [20, 21], drought [22].

Lectins of legumes are comprised of several subgroups of plant lectins. However, it is clear that despite the great similarity, which can be traced back to amino acid sequences of lectin polypeptides and nucleotide sequences of genes, different subtypes of legume lectins differ in molecular structure and specificity [23].

Moreover, some legumes (Ulexcuropacus, Griffoniasimplicifolia) are known to contain two or more lectins with different biochemical properties and specificity. For example, from some of the wild species of Phaseolus vulgaris lectin-like storage proteins arselins, consisting of two major and one collateral polypeptides have been isolated [24]. Legume lectins are involved in various processes of the plants vital cycle. One of the most important functions of hemagglutinating beans proteins is their participation in the formation of symbiotic nitrogen-fixing systems. With the help of hemagglutinins, the binding of nodule bacteria takes place, which promotes aggregation of rhizobia in the rhizosphere, and, in the future – the formation of nodules, in which atmospheric nitrogen is reduced [25]. Exogenous legume lectins are able to increase the adsorptive activity and virulence of specific nodule bacteria [26].

Beans is a culture with a high activity of lectins. Lectin content in the seeds of beans is quite large and comprises up to 2-10% of the total protein content [27]. The content of inhibitors in the seeds of leguminous plants is up to 5-10% of the soluble proteins. Cyanide content in the seeds of common bean (Phaseolus vulgaris L.) is 2.0 mg/100 g [28]. Lectins of beans have similar to insulin and radiotherapeutic activities, stimulate proliferation of lymphoid cells, possess immunostimulatory properties [29]. Lectins and hydrolase inhibitors of beans increase peroxidase activity, plant resistance to pathogens and phytophages, increase crop productivity [30, 31]. Russian scientists on the basis of bean lectins created preparation "Lel" for pre-seed treatment, which increases plant vigor and seed germination, reduces disease and pest infestation [16].

It is known that one of the main sites of synthesis and localization of lectins in plants, such as legumes and grasses, are in the actively growing tissues. Therefore, we can make an assumption about the importance of the implementation of lectins in division, expansion and differentiation of cells. However, despite intensive study on the functions of lectins, absolutely no data is available on the mechanisms of regulation of their activity. Literature contains fragmentary and contradictory information concerning the possible involvement of lectins with phytohormones in the regulation of growth processes in intact plants. In this connection it is important to study the accumulation of lectins in isolated cells and tissues. This assumption is based on data on the ability of the different lectins interact with phytohormones and participate in the hormonal regulation of plant growth and development [32].

The role of lectins in the formation of morphogenic type of callus was observed and the characteristics of accumulation of lectins in the presence of plant hormones were studied on wheat callus cultures [33]. The dynamics of lectin activity was studied on sugar beet calli inoculated with mollicut Acholeplasma laidlawii var.granulum. Activity of acid-soluble lectins of cell cultures of sugar beet increased after infection with aholeplazma [34].

Thus, since the plant lectins showed broad diversity in structure, carbohydrate specificity and localization in cells, tissues and organs, studies on the components of the protein complex of seeds and callus cultures of beans is certainly relevant to a creation of phytoimmunomodulators, plant protection products and pharmaceuticals, using biotechnological approaches, as products based on natural ingredients are environmentally sound and can replace chemical agents, used for protection.

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