



Shiitake mushroom, Japanese fragrant mushroom (*lentinula edodes* (derk.) pegler) in primorsky territory: distribution, nutritional and medicinal properties, artificial reproduction, mushroom status

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Abstract

This mushroom comes from Japan and is known under various names (Shiitake, Shiang-gu) and has amazing properties that have not yet been fully studied. Shiitake mushrooms are one of the most popular mushrooms in the world. They are valued for their rich taste and useful properties, which are now actively used in medicine and pharmaceuticals; they have an antitumor and excellent immunomodulating effect, and some even call these mushrooms the “elixir of life”. Shiitake was discovered and brought into use more than 2 thousand years ago, but in Russia it became known only in 1988 thanks to mycologist E.M. Bulakh. She discovered a previously unknown mushroom on the linden tree, and confirmed with numerous studies that it grows mainly in the southern regions of the Primorsky Territory and in the Far East. In 2008, the mushroom was listed in the “Red Book of Primorsky Territory”. However, in the course of field studies, we obtained new information and made conclusions regarding the exact range of the mushroom in the territory of the Primorsky Territory. This allows us to raise the question of changing the “red” status of shiitake and transferring it to the low risk category in order to popularize it among the population and efficiently use its unique nutritional and medicinal properties. In addition, the assignment of a new status will enable people to grow mushrooms in their greenhouses, on personal plots. Under favorable weather conditions, the mushroom yields a good harvest for 7-8 months a year, which allows expanding the range of winter harvestings.

Keywords: primorsky territory, wood-destroying mushrooms, nutritional and medicinal properties, mushroom status

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INTRODUCTION

Among all the known forest plants, mushrooms are a real storehouse of proteins. They contain about 30-40% of protein, carbohydrates and other substances useful for human health. The category “edible” includes all mushrooms that do not contain harmful components. At the same time, they should also have a good aroma and pleasant taste. In the Primorsky Territory, according to the data of the famous Soviet mycologist L.N. Vasilieva, no scientific research was carried out until 1945, which laid out an erroneous view about the small number of mushrooms in this region. However, a five-year study and field work carried out under the supervision of L.N. Vasilieva recognized that the region is one of the richest in this regard on the territory of the USSR. Thus, almost all types of edible mushrooms known to science grow in the region. There are chanterelles, birch boletes, morels,

honey agarics, and red pine mushroom. However, many of the varieties are no longer found in any region of the former Soviet Union. In her scientific work, mycologist E.M. Bulakh cited a list of such mushrooms: *Lactarius flavidulus* Imai, *Pleurotus serotinus*, *Pleurotus citrinopileatus*, *Rugiboletus extremiorientalis*, Shiitake and deadly poisonous *Lampteromyces japonicus* (Kawamura) Sing (Bulakh and Govorova 2000, Bulakh 2015, Vasilieva 1951).

Working on a scientific treatise, L.N. Vasilieva described in detail in the report all 47 species of mushrooms, accompanying them with illustrations and diagrams. After 20 years, she added to this list and already indicated 146 species of edible and 30 inedible

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mushrooms. At the same time, none of works paid attention to the Japanese mushroom Shiitake. There is no mention of this unique plant in the works by other famous scientists - B.P. Kolesnikov and L.V. Liubarskii (Kolesnikov and Liubarskii 1963).

In 2015, the book by E.M. Bulakh "Forest Mushrooms of the Far East of Russia" was published, where the mycologists describe in detail all edible and inedible mushrooms known to science. In total, this guide contains information with figures and diagrams about 446 species. At the same time, 220 of them are edible. This confirms how small a portion of mushrooms from a possible natural reserve is used by the inhabitants of the Primorsky Territory for food. Indeed, on average, local residents consume only 10% of the popular species.

The unique medicinal Japanese mushroom, which according to the classification currently belongs to the *Omphalotaceae* family of the *Basidiomycetes* class of the *Basidiomycota* division, is also little known to residents. This is a class of basidiomycetes that grow mainly in Asia. But today, scientists have discovered large areas of this mushroom in other territories, including the Philippines, Nepal, and Taiwan.

MATERIALS AND METHODS

The authors of this article conducted various studies on the territory of the Training and Experimental Forestry of the Primorye State Agricultural Academy, which occupied 46 thousand hectares. This area was transferred in 1960 to the Primorye Agricultural Institute, but since the 90s, due to the transfer to federal ownership, it has not belonged to the educational institution for a long time. Only many years later, after numerous negotiations and repeated appeals from the educational institute to the authorities, in 2009, it returned the land with an area of about 29 thousand hectares on loan. The rest of the territory, which once belonged to the training forestry, was transferred to the ownership of other owners, moreover, with permission to conduct business activities, which led to deforestation.

Near the experimental farm there is the "Vepr" hunting organization, which occupies 15 thousand hectares. The average composition of the forest stand of this territory can be described by the following taxation formula: 4D5Lp1K+Yas, I, Kl., age 110-160 years, forest density - 0.5. Underwood - 4D3K3Lp, 5 thousand units/ha, is trustworthy. In these forests, selective cutting of trunks of Mongolian oak is carried out almost annually, and here more than 10-year field research and monitoring of changes in the development of shiitake mushroom on chopping remains of hardwood species - Mongolian oak have been carried out here (Fig. 1).

Objectives of the research:



Fig. 1. Oak felling in the territory of the "Vepr" hunting organization

1. To clarify the area of shiitake mushroom in the Primorsky Territory.
2. To establish the exact yield of the mushroom on the cutting residues of oak throughout the year.
3. To develop methods for the artificial reproduction of shiitake mushroom on wood and sawdust of various tree species.
4. To study the features and timing of the development of mycelium on the cutting residues of oak, depending on the place of storage of heaps, weather and climatic conditions.
5. Based on current data on the natural distribution of the shiitake mushroom in the forest territory of the Primorsky Territory and the simplicity of its artificial reproduction, to solve the issue of changing the status of the shiitake with the aim of free use by the local population of the fruit bodies of the mushroom, which has good nutritional and medicinal properties.

RESULTS AND DISCUSSION

In the summer-autumn period of 2015, graduate student P.A. Komin organized numerous trips around Primorye in order to search for shiitake mushroom in other, more northern, areas of the Territory. Before the start of research activities with forestry workers, the locations of Mongolian oak timber harvesting with cutting residues were determined. In addition, work was carried out to identify the habitat of the mushroom in areas of once burnt wood (Fig. 2). Such field trips gave good results. During the expedition, the bodies of the mushroom were found on the dead wood of oak, linden, and birch in Spassky, Kavalerovskiy, Chuguevskiy, Dalnerechenskiy, Dalnegorskiy, Krasnoarmeyskiy, Pozharskiy, and Terney districts (Fig. 3).



Fig. 2. Graduate student of PSAA Pavel Komin conducts the registration of the harvest of shiitake mushroom

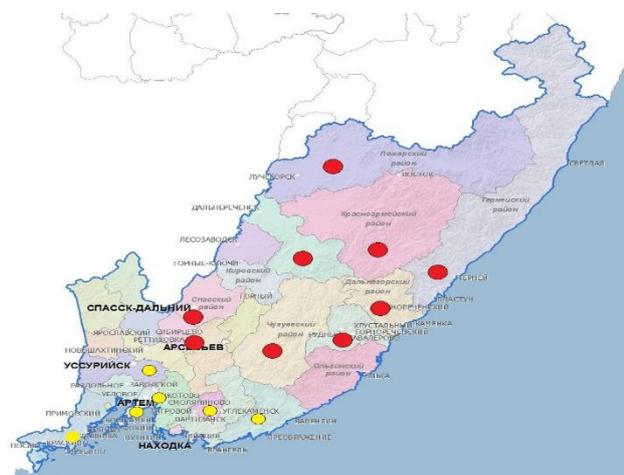


Fig. 3. Mushroom growth areas. The area studied by mycologist E.M. Bulakh is highlighted in yellow. Red color shows the territory of the research group of graduate student P.A. Komin



Fig. 4. In spring, the cap of the shiitake mushroom is actively eaten by mice and chipmunks, the stipe of the mushroom remains untouched due to its stiffness

Description of the Mushroom

The size of the cap of this mushroom is approximately 5-10 cm. It is convex, brownish, with a slight darkening in the center. The stipe reaches 1 cm in thickness. It has a dense, almost solid structure, so the stipe cannot get broken and torn off the substrate, it can only be cut with a knife near the cap, thereby preserving the substrate mycelium for the further growth of fruiting



Fig. 5. Shiitake mushroom in a dry, mature form contains the greatest number of medicinal properties



Fig. 6. Shiitake mushrooms collected in the forest plot of PSAA on November 10, 2012

bodies. The fruiting bodies of the mushroom in the Primorsky Territory begin to develop from mid-April and serve as the main food for many forest inhabitants at this time (Fig. 4).

In the process of aging, the cap and stipe change their color, acquire a brownish tint. In some places, separate yellowish spots first appear, which gradually increase and already occupy the entire area of the mushroom. It should be recalled that the homeland of these mushrooms are Japan and China, where they have been grown for more than 2 thousand years. And only in recent decades their medicinal and nutritional properties have been fully studied. Shiitake are mushrooms that naturally grow on decaying deciduous trees. About 83% of this product is today grown in Japan, although it is also produced by the United States, Canada, Singapore, and China. If we talk about the nutritional value of these mushrooms, then it is extremely high.

They really began to study shiitake only in recent decades, and now the results of such an analysis are impressive. The amount of active compounds in a shiitake depends on how and where they grow, are stored and prepared. Mushrooms destroy trees and feed



Fig. 7. Shiitake mushrooms collected in the forest plot of PSAA on November 10, 2012

on the organic remains of plants. As a rule, they live on dead wood. The most extensive places of growth can be found in burned areas. During a study of the Primorsky Territory on the subject of studying the shiitake area, it was revealed that the mushroom grows mainly on dead oak wood. But there have also been cases of settlement on birch, alder and other deciduous tree species.

In the course of field studies, our group found that natural infestation with spores of oak felling residues is possible within 2-4 years under favorable weather and environmental conditions. On semi-decomposed substrates, the mushroom bears fruit annually for the longest period. Young mushrooms appear already in the second decade of April, and the late harvest can be harvested even at the end of October - November. On the same logging residues, the mushroom bears fruit throughout the growing season. From the appearance of tiny, pin-headed, brownish balls to a well-developed mushroom with a cap diameter of up to 10 (20) cm and a weight of up to 80 (100) grams, an average of 10 days pass.

Depending on the weather, the body of the mushroom gradually loses moisture and begins to dry out, crack. In this state, it can stay long enough, while continuing to be suitable for storage and preserving all its useful properties (**Fig. 7**).

For the preparation of various food additives and medicines, shiitake is used in powder form. In this case, the dry body of the mushroom which in this state has a maximum concentration of nutrients, is grinded. With increased humidity, the mushroom quickly loses its nutritional properties, is filled with water, darkens and rots.

Observing the mushroom family, we can find that they are all at different stages of their development. There are only the stalks that have appeared, and half-dried bodies. As all mushrooms of this class, the spores of the shiitake are located on the underside of the cap. Maturity period of spores is 10-14 days. They are quickly carried by the wind and, settling on the deadwood, infest

the wood with large felling residues. Our preliminary calculations showed that on average per 1 ha there are up to 10-15 heaps of felling residues containing 2 or more cubic meters of abandoned oak wood. After 3-4 years, the first shiitake mushrooms appear on stumps, large and small decaying felling residues, which, depending on the weather conditions of the growing season, bear fruit from April to November, that is, almost eight months.

Within the growing season, the yield of this mushroom will be uneven. In the spring, in April-May, the first "outbreak" is observed. All felling residues were filled with moisture from melting snow, mycorrhiza easily breaks down rotten oak cellulose and uses the resulting nutrients on the growth of fruiting bodies.

During this period, one hectare of forest where selective cutting of Mongolian oak took place, may bear several tens of kilograms of a valuable nutritional and medicinal product. In the future, the yield of this mushroom will depend on the weather conditions of summer and autumn.

With frequent and heavy rains, the fruiting bodies of the shiitake will appear more or less evenly on the same felling residues. In dry weather, the rudiments of fruiting bodies dry out, not reaching the desired size.

Thus, with the regular collection of mushrooms on the areas of selective cutting of Mongolian oak, the yield can reach 100 kg per 1 hectare in one year. We noticed that the duration of the shiitake yield, and, consequently, the collection of these mushrooms on old heaps of felling residues usually does not exceed 10 years.

Spent wood residues of any size become dry, light, lose their former appearance and turn into dust. The tree-destroying shiitake mushroom has completely done its job.

New felling sites and almost annual forest fires make it possible for these mushrooms to find new objects for life with the help of a huge number of light spores, thereby expanding the area and increasing the yield of valuable mushrooms.

Nutritional and Medicinal Properties of the Mushroom

Numerous scientific experiments in laboratories revealed that the shiitake mushroom has a wide range of useful properties and can be used not only in the food industry, but also in pharmaceuticals (Li et al 2009, Flora 2002, Hongo 1960, Imai 1938, Kim 1990, Staimets 1983, Teng 1996, Ying et al. 1987)

Medicinal mushrooms have a long history of use in traditional oriental medicine. Recent studies have confirmed and documented most of the ancient knowledge.

In modern clinical practice in Japan, China, Korea and other Asian countries, drugs based on shiitake powder are used. Mushrooms were studied for nutritional and medicinal purposes to identify the

possibilities of their use. The antitumor and immunomodulating compounds found in their composition, such as polysaccharides, became the impetus for the development of new drugs. In medicine, mushrooms are used to prevent cancer and heart disease, to improve blood circulation and lower blood cholesterol.

The powder is used in production of medicinal drugs to treat physical and emotional stress, osteoporosis, gastric ulcer, and chronic hepatitis, to improve the quality of life of patients with diabetes, and especially to stimulate the immune system. Mushrooms have the ability to increase the body's resistance to many diseases by providing it with important vitamins, minerals, and enzymes. Shiitake is rich in styrene compounds that inhibit the production of cholesterol in the liver. They also contain powerful phytonutrients that help prevent cells from adhering to the walls of blood vessels and causing plaque, which maintains normal blood pressure and improves blood circulation. Mushrooms are saturated with vitamins B, which are responsible for the functioning of the adrenal glands, contribute to the normalization of hormonal levels and prevent brain aging. Another important property of this product is the provision of vitamin D. Although vitamin D is best produced in the sun, shiitake mushrooms can also be a good source of the much-needed element in the body. Getting enough vitamin D helps regulate and maintain the immune system, a healthy body weight, brain function as you age, reduce the severity of asthma symptoms, and reduce the risk of rheumatoid arthritis in women, and multiple sclerosis.

The Status of Shiitake Mushroom in the Primorsky Territory

In the Primorsky Territory, shiitake mushroom still has a rare status and is listed in the Red Book, which excludes the possibility for the local population to actively use its beneficial properties. To assign status according to international standards, its own classification into 9 categories (IUCN) is used. All types of flora and fauna fall under these standards. Shiitake mushroom is listed in the Red Book marked VU - "vulnerable". Due to the high risk of disappearance, it is protected at the level of the law, and at the legal level its use for any purpose is completely excluded.

Today, the leadership of the Primorsky Territory sees the development of the regional economy as one of the priority areas. This, in turn, will create an additional burden on the environment, as the demand for medicinal plants of the Primorsky Territory, including shiitake, will increase. Considering that several millennia ago this mushroom grew under artificial conditions in Asia as a cure for many diseases, it is now extremely unfair that local residents are deprived of the opportunity to use the gifts of nature in natural conditions.

To understand how the chronology of the discovery and research of this mushroom developed, we shall recall the basic facts.

1. During the first scientific expedition by mycologist L.N. Vasilieva, a large number of edible and inedible mushrooms were identified and classified. However, the researcher makes not a single mention of shiitake in the scientific works.

2. Shiitake was discovered and brought into use more than 2 thousand years ago, but in Russia it became known only in 1988 thanks to mycologist E.M. Bulakh. She discovered a previously unknown mushroom on the linden tree, and confirmed with numerous studies that it grows mainly in the southern regions of the Primorsky Territory and in the Far East. In 2008, the mushroom was listed in the Red Book of Primorsky Territory.

3. In the course of field studies, graduate student P.A. Komin found several places where shiitake mushroom grows in the Primorsky Territory. The regions where the mushroom was discovered are indicated on the map (**Fig. 3**). This allows us to conclude that the mushroom expands its habitat and gradually grows in the forest zone of the Primorsky Territory.

The main focus of contamination with spores is dead wood and felling residues of the oak forest, but in rarer cases, mushrooms can be found in birch, alder, and linden forests. The mushroom spreads through spores that are very quickly carried by the wind and settle on dilapidated trees. This suggests that human in this chain plays only an indirect role, cutting down the forest or being the culprit of the fire. What effect does mushroom picking have on their population? Given that the mushroom leg is very hard, it is not easy to break or tear off the substrate. So, the cap is mainly used as a crop. The stipe can be removed only with a knife. This indicates that the mycelium during the collection of mushrooms is not disturbed, which means that there is no direct threat to reducing the population.

The mushroom bears fruit for 5-7 months a year, from mid-April to the first frosts in October-November. The stipes left after harvesting do not interfere with the development of the mycelium of the mushrooms in dead wood; therefore, the collection of the fruits of the mushrooms does not affect the quantity and quality of the population.

4. The authors of this article suggest that the relict and medicinal shiitake mushroom itself, without any human intervention, increases its area, occupying new forest spaces with the help of numerous, very small and light spores, able to cross many tens and hundreds of kilometers of land by wind or sea (**Fig. 8**).

For more than 10 years, the Institute of Forestry Management of the Primorye State Agricultural Academy has been working on the artificial cultivation of fruit bodies of shiitake mushroom. The experiments of a graduate student P.A. Komin proved that the mushroom develops well and gives a good harvest of fruiting bodies

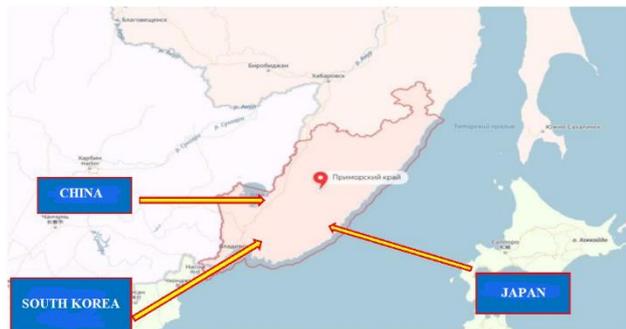


Fig. 8. The supposed occurrence of shiitake mushroom in the Primorsky Territory

on sawdust of conifers and various deciduous trees. The teachers of the Department of Forestry (Prof. Gukov G.V., Associate Professor Rozlomii N.G., graduate student Komin P.A.) also developed a method for growing shiitake mushroom in large areas. The method is quite simple to implement, is brought into practice on the territory of the Training experimental forestry of the State Agricultural Academy, and consists of two stages.

Harvesting of the Substrate. Creation of Chopping Heaps

The main areas of the training experimental forestry are occupied by secondary oak forests, with a predominance of Mongolian oak and a number of deciduous species - Manchurian and Daurian birches, aspen, alder, linden, etc. Since oak is the main mycorrhiza, the future substrate for many intended for artificial mushroom cultivation will consist mainly of oak wood. In separate, lower places, several trees are cut down, trunks and branches are divided into 1-2-meter sections and stacked in heaps in the form of felling residues. The size of the heaps should be up to 2-3 m in diameter and up to 1.5 m in height. Heaps are recommended to be placed in the shade of the remaining trees or their groups to prevent them from drying out quickly. When stocking twigs and brushwood, try to make it denser and more compact. To do this, the thicker and larger parts of the trunks and branches are laid in the lower part of the heap so that they fit snugly on the ground. It is useful to crush the finished pile from above with a large-sized heavy segment of the trunk. It is tentatively supposed to place 4-5 such heaps on 1 ha; with positive results, the number of growth sites of wood-destroying mushrooms in the green zone of forests can be increased.

Infestation of Decaying Heaps with Mycelium of Wood-destroying Mushrooms

The nature of the Far East and Primorsky Territory is rich in mushrooms and allows people to harvest them in sufficient quantities. However, mycelium can accumulate substances harmful to humans - heavy metals, radioactive elements, pesticides, etc. from the air, groundwater sediments and store them in the

mushrooms. Given that there is a global environmental degradation, therefore, mushrooms cultivated in artificial conditions are safe and environmentally friendly. Isolation and maintenance of pure cultures, the creation of an in vitro collection is one of the primary techniques preceding any laboratory research related to microorganisms.

The laboratory of agricultural biotechnology, Federal State Budgetary Scientific Institution, A.K. Chaika Federal Scientific Center for Agrobiotechnologies of the Far East" (Ussuriysk, village Timiryazevsky) have studied issues related to the cultivation of edible mushrooms for more than 25 years. Shiitake mushroom, which has good nutritional and medicinal properties, is used by locals. Three strains of it are stored in the laboratory. The introduction of the shiitake mushroom into in vitro culture begins with plating part of the fruit body (isolate) on the nutrient medium in a Petri dish. After the initial growth of mycelium, isolates are carefully selected without fungal and bacterial infection. Part of the mycelium with the nutrient medium is transplanted from this culture into a test tube and further control of the purity of the selected culture is carried out. The inoculating shiitake mycelium is prepared according to the generally accepted method using oat grain. The grain substrate is packaged in glass bottles, where the mycelium grows, and within 20-22 days the substrate is completely colonized by mycelium.

After lying for 2-3 years in wet heaps, hardwood (Mongolian oak) wood decomposes, loses its structure, which allows the grain substrate, which fell into the lower parts of the harvested heaps, to germinate and form strands of mushrooms, called mycelium. When growing, the mycelium extracts water with various minerals from decaying wood and forms fruiting bodies in the coming years. The process of infestation of heaps by wood-destroying mushroom mycelium is quite simple and does not require significant financial and material costs. To complete the work, it is necessary to purchase grain mycelium and engage several workers whose task will be to decompose the grain mycelium into previously prepared wood heaps. To avoid drying out of the mycelium, the grain mycelium is placed in the lower parts of the oak heaps. This will help extend the life of the mushroom family. Thus, such events will allow to control the increase in the range and increase the efficiency of cultivation of Japanese mushroom. This, in turn, will make it possible to remove the status protected by the Red Book from the Shiitake mushroom. Summing up, it should be said that the collection of mushrooms in no way reduces the yield and does not negatively affect the spread of the mushroom in the forest area.

In this regard, we propose to change the status of the shiitake mushroom to "LR - low risk", which will allow local residents to harvest it. In addition, it is necessary to organize control over the state of the forestry economy of the Primorye State Agricultural Academy and develop

a set of measures for sanitary deforestation, clean up the territory of Mongolian oak felling, continue field work on the artificial infestation of felling residues of Mongolian oak with shiitake mycelium. At the moment, the Agricultural Academy is already conducting research on the artificial cultivation of shiitake mushroom on hardwood cuttings and on sawdust of various coniferous and deciduous trees. Despite the fact that the Japanese mushroom is not yet completely settled in the Primorsky Territory, its range, as shown by numerous studies, increases every year.

An example of annual felling of Mongolian oak in the former territory of the Training and Experimental

Forestry of the Primorye Agricultural Institute shows that after a maximum of 5 years, several kilograms of the relict mushroom can be harvested by the local population from felling residues.

The mushrooms can be easily grown in the garden, along with potatoes and other vegetables, on oak wood, which will allow you to collect a valuable product for several months - from April to November. Maintenance of such a mushroom plantation is quite simple - locate it in a slightly shaded place and, if necessary, moisten so that the wood is constantly in a wet state for the development of mycelium and fruiting bodies.

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