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**THE ROLE OF INTERDISCIPLINARY SCIENTIFIC RESEARCH
IN FORMING SPECIALISTS OF FOOD BIOTECHNOLOGY**

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Abstract

The scientists of many countries understand the importance of educating future researchers using an interdisciplinary approach. Microbiological safety of food and biotechnological products, raw materials is one of the main scientific research area. The article presents the results of interdisciplinary study of mold fungus *Fusarium* spp. causing potato dry rot and influence of biologicals “Alirin-B” on fungi reproduction system, chemical properties of potato pulp, possibility of organic potato using in food industry and catering. The data were obtained by research methods of such discipline as microbiology, morphology, botany, biotechnology, mathematics, computer programming, agriculture, food technology, economy. Students studied on the bachelor's and master's programs acquire competencies that enable them set a comprehensive assessment of food product quality and safety. They are able to detect the quality of raw materials, to select the optimal chemical composition of raw material, product additives, storage conditions for raw materials and food products in order to prevent microbial contamination. On data obtained future specialists in the field of food science and biotechnology could use organic raw material in semi-finished production at public catering enterprises. It's shown the importance of interdisciplinary scientific research for formation of biotechnology and food science specialists, integration of fundamental science and real economy. The article based on the own empirical material shows the integration process of related project scientific researches in the priority direction “Living systems” for the biotechnology and food science development.

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1. Introduction

Scientists from different research fields agree on the development of interdisciplinarity to solve the grand challenges facing society - energy, water, climate, food, health. Rzheutskaya & Kharina (2017) approve that the problem of interdisciplinary cooperation is the key one for university lecturers when putting the competence approach into practice; according to the state educational standards, cultural and professional competences are integrative and must be developed in the process of studying various subjects. One more goal to be achieved only by means of realizing interdisciplinary cooperation is the development of professionally important personal qualities among the future engineers.

Interdisciplinary collaboration, particularly between natural and social sciences, is perceived as crucial to solving the significant challenges facing humanity. Scientists in many countries understand the importance of educating future researchers using an interdisciplinary approach. Barthel & Seidl (2017) describe the following forms of collaboration among disciplines:

Cross-disciplinary (CD) describes the loosest and least specific form of collaboration among two or more scientific disciplines, without a closer description of the purpose and the methodology the involvement.

Multidisciplinary research is more intense than CD because it has a clear purpose of joint problem solving by involving different disciplines.

Interdisciplinary entails the most intense collaboration, involving the dissolution of disciplinary boundaries, from the problem definition to the methodology. Interdisciplinary study is a process of answering a question, solving a problem or addressing a topic that is too broad or complex to be dealt with adequately by a single discipline, and draws on the disciplines with the goal of integrating their insight to construct a more comprehensive understanding.

Transdisciplinary is defined as the cooperation between scientists in academia and practitioners, decision makers or the public at large, which is not examined in this study.

The spirit of interdisciplinary research lies at the core of basic science. For example, Gill et al. (2015) point on the importance of interdisciplinary research training and community dissemination for medical university students. Turner et al. (2017) describe the interdisciplinary research programs on transporting ideas between marine and social sciences, which are implemented at the Gothenburg Centre for Marine Research of the University of Gothenburg. Holm et al. (2013) approve that Global Change Research studies involve the social, human, natural and technical sciences in creating the interdisciplinarity spaces.

Monitoring student satisfaction with education quality has become an integral part of the educational process in a number of European and Russian universities, which are interested in education quality improvement. Peter the Great St. Petersburg Polytechnic University, one of the leading universities in Russia, implements the policy targeted at increasing student satisfaction with higher education quality by increasing student involvement into the educational process, when not only the academic staff and administration participate in the improvement of higher education institution's activity (Razinkina et al., 2018; Alexankov, Trostinskaya, & Pokrovskaya, 2018). Bachelor and master participation in interdisciplinary scientific research is one of student activity form and student satisfaction.

Graduate School of Biotechnology and Food Science Peter the Great St. Petersburg Polytechnic University suggests the following Bachelor's Degree Programs: Food Biotechnology, Biotechnology of processing of raw materials and secondary bioresources, Technology of production and organization of restaurant business, Technology and organization of industrial production of culinary products and confectionery. Technology of production and organization of public catering.

The Master's Degree Programs has two programs: BioNanoTechnology and Technology of production and organization of public catering.

Students study fundamental and special disciplines, as well as participate in interdisciplinary research. Safety of food and agricultural products during production and turnover is a keystone in development of food market in many countries, including in Russia (Khokhlova & Khokhlova, 2016).

Nutrition has always been and remains the main human need. Human food consists of the same natural ingredients that are found in soil, water and air. Food with a variety of different nutrients is the main material for the construction of various tissues, organs and cells of a living organism.

Its full value and quality of more than 50% due to the quality of our lives. Zabolotnih (2014) described that the urgency of food quality and safety increases every year - this is one of the main factors determining the health of people and the preservation of the gene pool. Safety of and agricultural and food products during production and turnover is a keystone in development of food market in many countries.

Microbiological safety of food and biotechnological products, raw materials is one of the main theme of scientific research (Bazarnova, Samorukov, Zhilinskaya, & Ivanchenko, 2015).

Interdisciplinary research carried out by students under professor guide include the following investigation lines:

- raw materials using in food biotechnological production;
- modern biological protection of food and biotechnological raw materials during storage;
- food and biotechnological product design;
- innovative technologies for food and biotechnological products in food industry and public catering.

The article presents the potato scientific research data. Potato is one of the leading agricultural crops in many countries and used as raw material for many product types in public catering and food industry. The researches were carried out in the Graduate School of Biotechnology and Food Science Peter the Great St.Petersburg Polytechnic University. Professors reported the interdisciplinary research data on lectures for students.

Despite the fact that the potato is a high yielding culture, total number of potato tubers has significantly reduced in some years. The main reason of the potato harvest decrease is the damage of the potato tubers by bacterial and fungal infections such as *Phoma rot*, late blight, *Fusarium*, etc. (Stefańczyk, Sobkowiak, Brylińska, & Śliwka, 2016). Sporulation is the main way of fungal reproduction by macro- or microconidium which are varied in shape, size and structure. These fungi may contaminate food products with mycotoxins, threatening to animal and human health.

2. Problem Statement

Possibility of applying different discipline methods for complex potato and potato products interdisciplinary research.

Potato tuber bioprotection against microbiological contamination.

Using organic potato in food industry and catering.

3. Research Questions

Study digital morphometric and bioinformatics characteristics of *Fusarium* spp. causing potato dry rot.

Study the influence of biological fungicidal commercial product “Alirin - B”.

Study of physical and chemical properties of potato.

Criteria of food raw material safety.

4. Purpose of the Study

Prove the influence of biological fungicidal commercial product “Alirin - B” on *Fusarium* spp. causing potato dry rot.

Prevention of potato tuber against microbial contamination during storage.

Determination of vitamin C in raw and boiled potato pulp.

Development of assortment and improvement of technology of semi-finished products from organic potato.

Proving the importance of interdisciplinary study of potato protection against microbiological contamination during storage and food technology production, using fundamental and special disciplines in fields of chemistry, biology, biotechnology, bioinformatics, agriculture, ecology, food science, economy.

5. Research Methods

The object of study were “Nevskiy” potato tubers grown in the Leningrad region (Russia) which were being in storage for 3 months after the 2017 harvest.

Tubers with mold fungus *Fusarium* spp. (*Fus. spp.*) contamination signs were selected. Three areas of the damaged potato tuber tissue were studied:

- - outside the epicenter of contamination;
- - peripheral area of tissue contamination;
- - the epicenter of contaminated tissue.

Microbiological study of potato tuber tissues was carried out by method of horizontal sampling techniques from surfaces using contact plates. A glass slide was applied for 5-10 seconds to each areas of contaminated potato tissues. Samples of potato tissues were stained by 1 % methylene blue solution. Microorganism fixed preparations were observed on digital microscope "Nicon Eclipse Ni". Morphological and morphometric macroconidium *Fus. spp.* cell characteristics (number, square,

perimeter, length) were obtained by automatic digital programme “Image J”, under magnification x 400 or x 1000.

In order to study the biological protection methods during potato storage the authors have used Alirin B1 - the basic component of a fungicidal preparation produced by the *Bacillus subtilis* 10-VIZR strain (Novikova, Litvinenko, Boikova, & Kalko, 2003). The fungal mycelium from epicenter of contaminated plant tissue was taken in the 5 % glucose solution. Two types of samples were researched: glucose solution with fungal mycelium (control), glucose solution with fungal mycelium and “Alirin - B” (experiment). The dynamic of “Alirin-B” influence on *Fus. spp.* macro- and microconidium was studied on 2 hours, 2 days, 6 days after its adding to the 5 % glucose solution with fungal mycelium.

Vitamin C in raw and boiled potato pulp was determined by Indophenol Method (Vasanth Kumar, Ajay Kumar, Raghu Patel, & Manjappa, 2013).

Statistics – by Graph Pad Prism 6.

For setting the shelf life of semi-finished products from potato, there were determined organoleptic, physicochemical and microbiological indicators of quality and safety.

6. Findings

The results of microscopic study of potato tuber tissues contaminated by *Fus. spp.* are shown on Fig.01.



Figure 01. Macro- and microconidia of *Fus. spp.* in potato dry rot tuber tissues.
400 x.

Earlier, Zhilinskaya et al. (2016) showed that *Fusarium* cells have their individual morphometric and bioinformatic characteristics in different contamination zones. The data obtained demonstrate a high degree of orderliness and relative organization in microbial cells contaminating potato tubers.

It's known that *Fusarium* phytopathogenic fungi contaminates different vegetable types and is a parasite. The fungi cells penetrate plant tissue and multiply in it by activating their metabolism (Manikandan, Harish, Karthikeyan, & Raguchander, 2018), secrete mycotoxins. Such secondary fungal metabolites is ecologically significant and confers increased fitness to the microorganism producing (Mejdoub-Trabelsi, Jabnoun-Khiareddine, & Daami-Remadi, 2015).

We have studied the fungicide biologics influence on *Fus. spp.* causing potato dry rot during its storage using Alirin B.

The results of computer morphometric measurements macroconidia cells in the experimental samples were following. On 2 hours: the area size was $35,22 \mu\text{m}^2 \pm 11,30$; the cell length – $16,75 \mu\text{m} \pm 2,96$; the cell width – $2,29 \mu\text{m} \pm 0,28$, the amount of sprouted macroconidia was 0 %. On 48 hours: the area size was $58,23 \mu\text{m}^2 \pm 13,44$; the cell length – $21,99 \mu\text{m} \pm 4,23$; the cell width - $2,84 \mu\text{m} \pm 0,17$, the

amount of sprouted macroconidia was 43 %. The microconidia cells area size was: $3,78 \mu\text{m}^2 \pm 0,19$ (2 h), $3,52 \mu\text{m}^2 \pm 0,26$ (48 h). On 144 hours: macroconidia and microconidia were not found.

Quantify results showed that “Alirin-B” especially effects on fungi microconidia: there number was decreased from 40 % (2 h) to 25 % (2 days) and to 0 % (6 days). The number of macroconidia was increased at first time from 14 % (2 h) to 74 % (2 days) and then decreased to 0 % (6 days).

Potato seeds and tubers treated with biologics are the raw materials for the organic food production.

Knowledge of raw material physical and chemical properties is necessary in the production of biotechnological and functional products. For example, vitamin C (Ascorbic acid) is the most important vitamin in fruits and vegetables. More than 90% of the vitamin C in human diets is supplied by vegetables (including potatoes) and fruits. As an antioxidant, it reportedly reduces the risk of arteriosclerosis, cardiovascular diseases (Moser & Chun, 2016) and some cancer diseases (Szalay, 2017).

Vitamin C amount (mg/100 g sample) was determined in raw potato pulp and in potato pulp after 10 minutes in boiling water. The data obtained show that vitamin C amount in raw potato pulp was $9,3 \pm 1,4$ mg/100 g, vitamin C amount in raw potato pulp after boiling was $5,0 \pm 1,6$ mg/100 g. The result shows that vitamin C remains in potatoes even after cooking in boiling water. This data confirms the usefulness of potato products.

That is why the students research not only the questions of food raw material safety, but also the questions about raw material usage in the organic food production. Therefore, knowledge obtained in previous interdisciplinary research, students use in study of new technologies in organic food or semi-finished production.

There were solved following tasks in our work:

- the choice of raw materials from vegetables cultivated in the North-West region is grounded;
- there was developed a scale of sensory characteristics for the evaluation of organoleptic indicators of semi-finished products from organic potato;
- there was developed a technological process for the production of vegetable semi-finished products;
- there was assortment of semi-finished products from organic potato were recommended for using at various types of public catering enterprises;
- a plan of measures to ensure product safety was set;
- there were composed technical conditions and technological instruction for semi-finished products from potato.

In the course of the study, it was found that during storage in warehouses and refrigerated storage a decrease in antioxidant activity is observed, which leads to a change in the chemical composition and, as a consequence, loss of nutritional value. The amount of loss depends on the type of vegetables (large losses in potatoes).

During the interdisciplinary research work the student acquire knowledge obtained during the previous discipline study (Table 01):

Table 01. Disciplines used in scientific research of raw material (potato) and food products

No	Scientific Research Direction	Discipline name
1	Potato microbiological contamination	Microbiology, Botany, Plant morphology, Ecology, Agriculture, Computer programming, Bioinformatics
2	Potato biological protection	Microbiology, Botany, Plant morphology, Ecology, Biotechnology, Agriculture, Computer programming, Bioinformatics, Economy
3	Physical and chemical properties of raw and boiled potato pulp	Chemistry, Botany, Physics, Food Chemistry
4	Innovation technologies in food industry and catering	Technology of public catering products, Microbiology, Biotechnology, Computer programming

Theoretically, the risks that arise in the production of semi-finished products are determined, the main of which is the development of microorganisms and the laborious process of their detection. Therefore, it is necessary to improve express methods for detection of microorganisms, so that they become available for all types of public catering establishments and used by enterprises themselves to control the quality of semi-finished products and finished products at the required stages of production (Kutkina, Kotova, & Eliseeva, 2016).

Knorr & Khoo (2015) point to the importance of working toward a future agenda in which interdisciplinary research becomes the norm and food science is better integrated in biomedical research.

Modern higher education imposes requirements both as to the level of professional competencies and as to the social and individual intelligence increasing, consciousness and spirituality, human ability to design and forecast. Interdisciplinary scientific research is one of the modern education information technology paradigm link in which the focus has finally shifted to a technical component, which has now permeated all spheres of social life, all current and forthcoming processes (Aladyshkin, Kulik, Michurin, & Anosova, 2017).

7. Conclusion

It's important to use different academic discipline methods in interdisciplinary scientific researches providing by students.

Biologicals "Alirin-B" obliterates macro- and microconidia and thus affects on *Fus. spp.* reproduction system. The study was carried out using research methods of such discipline as microbiology, biotechnology, mathematics, computer programming, agriculture, economy.

Determination of vitamin C in potato pulp after cooking in boiling water confirmed the fact that potato is a functional product. The study was carried out using research methods of such discipline as Chemistry, Botany, Physics, Food Chemistry.

Students studied on the bachelor's and master's programs acquire competencies that enable them set a comprehensive assessment of the quality and safety of food products. They are able to detect the quality of raw materials, to select the optimal chemical composition of raw material, product additives, storage conditions for raw materials and food products in order to prevent microbial contamination.

On data obtained future specialists in the field of food science and biotechnology could use organic raw material in semi-finished production at public catering enterprises.

The data obtained could be used in the development of digital programs for the calculation, formulation, prediction of the contaminant composition, determination of the maximum possible number of additives, etc.

The data obtained point at the importance of interdisciplinary scientific research for formation of biotechnology and food science specialists, integration of fundamental science and real economy.

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