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Aims and Scope

The aim of “Annals of Agrarian Science” is to overview problems of the following main disciplines and subjects: Agricultural and Biological Sciences, Biochemistry, Genetics and Molecular Biology, Engineering, Environmental Science. The Journal will publish research papers, review articles, book reviews and conference reports for the above mentioned subjects.

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Verification of WRF simulated accumulated precipitation

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A B S T R A C T

Purpose of this study is investigation of Advanced Research Weather Forecasting Model's (WRF-ARW) skill in Quantitative Precipitation Forecasting for Georgia's conditions, where orographic features play key role in modeling convectional processes. The Country territory is prone to flash floods and mudflows, Quantitative Precipitation Estimation (QPE) and Quantitative Precipitation Forecast (QPF) on any leading time are very important for Georgia. We have analyzed several convection parameterization and microphysical schemes combination for different rainy episodes and heavy rainy phenomena. We estimate errors and biases in accumulated 6 h precipitation using different spatial resolution during model performance verification for 12-hour and 24-hour lead time against corresponding rain gauge observations and satellite data. Various statistical parameters have been calculated for the 8-month comparison period and some skills of model simulation have been evaluated.

Keywords: Air mass convection, Numerical weather prediction (NWP), Quantitative Precipitation Forecasting (QPF), False alarm, Extremal Dependence Index, Contingency table.

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Introduction

Precipitation forecasts are one of the most demanding applications in numerical weather prediction (NWP). Georgia, as the whole Caucasian region is characterized by very complex topography. Such complex character of the relief and the vicinity of the Black and Caspian seas considerably deforms large-scale (synoptic) processes and causes formation of local and regional peculiarities of atmospheric processes and strong spatial inhomogeneity of meteorological fields and mainly determines the precipitation regime all over the territory of Georgia. The climatic picture totally differs in both parts of Georgia as divided by the Likhi Range. The Black Sea influences the climate of West Georgia, resulting in abundant precipitation. The climate in the plains of East Georgia is dry. The annual amounts of precipitation vary in the range of 400-600 mm

in the plains, and 800-1,200 mm in the mountains.

Taking into account above mentioned orographic and synoptic complexity simulation results from regional NWP do not have the same quality for all areas within the domain. This is especially evident for precipitation quantitative forecasts, where in contrast to other forecast variables, generally no significant improvement could be achieved in the last decade [1-4]. Quantitative Precipitation Forecasting (QPF) on regional scales is still inadequate for many applications such as in hydrology and flood forecasting. For this purpose, it is essential to simulate precipitation accurately down to the size of small catchment areas. Our focus is on the formation and organization of convective precipitation systems in a low-mountain region. Several problems in connection with QPF have been identified for mountain regions, which include the overestimation and underestimation of precipitation on the windward and lee side of the

mountains, respectively, and a phase error in the diurnal cycle of precipitation leading to the onset of convective precipitation in model forecasts several hours too early [5-7].

Many countries have national rain gauge networks that provide observations that can be used to verify the model QPFs. Since rainfall depends strongly on atmospheric motion, moisture content, and physical processes, the quality of a model's rainfall prediction is often used as an indicator of overall model health [8-10].

Purpose of this study is investigation of Advanced Research Weather Forecasting Model's (WRF-ARW) skill in Quantitative Precipitation Forecasting for Georgia's conditions, where orographic features play key role in modeling convective processes, testing several convection parameterization and microphysical schemes, as well as estimation errors and biases in accumulated 6 h precipitation using different spatial resolution for verification model performance against observations.

1. Data and method

The strategy for any forecast verification application includes certain rational steps: choosing and matching a set of forecast/observation pairs, defining the technique to compare them, aggregating (pooling) and/or stratifying the forecast/observation pairs in appropriate data samples, applying the relevant verification statistics and, ultimately, interpreting the scores, not forgetting to analyze the statistical significance of the gained results. Deterministic QPFs can be formulated and taken

as either categorical events or continuous variables and verified correspondingly utilizing respective verification approaches and measures [11-13]. Verifying QPFs as categorical events is clearly more common. The categorical approach involves issues like whether or not it rained during a given time period (rather than at a given instant) or, alternatively, whether the rainfall amount exceeded a given threshold. Verifying rainfall amount as a continuous variable brings about certain caveats because the rainfall amount is not a normally distributed quantity. Very large rainfall amounts may be produced by a forecasting system and, then again, in some cases very little or no rain. Many of the verification scores for continuous variables, especially those involving squared errors, are very sensitive to large errors. Consequently, categorical verification scores provide generally more meaningful information of the quality of the forecasting systems (or skill of the human forecasters) producing QPFs [14-15].

The WRF-ARW version 3.1 model was running operationally on the NEA cluster during several months with two different model configuration combining different convective and microphysical schemes. The simulation was run using the Betts-Miller-Janjic (BMJ) parameterization, which is based on the Betts-Miller convective adjustment scheme, Betts and Miller (1986), with Lin microphysics scheme, for mother domain and the same convection scheme with WRF single-moment 6 class microphysics scheme for nest. All simulations used the Yonsei University Planetary boundary layer schemes, 5-layer soil model for Surface layer and Dudhia's Shortwave and RRTM Long wave radiation

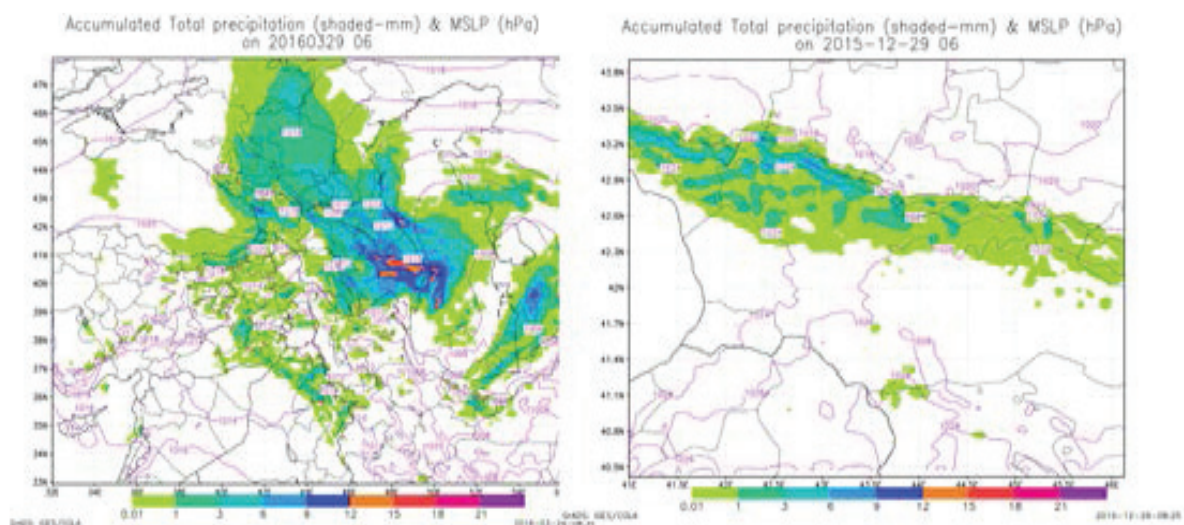


Fig. 1. 6 h total accumulated precipitation from mother and nested domain of WRF-ARW model.

As station data are point based and model output data are gridded we extracted time series from model output GRIB files for comparison

schemes. The model performance was carried out with two way nesting option.

For the study 6 hourly accumulated precipitation sums from 70 automated weather stations (AWS)/ posts and rain gouges were used (see fig.1). The number and spatial coverage of precipitation measurement points is not sufficient for the characterizing precipitation pattern across the country. Especially, when in mountainous parts of country we have very few stations or none at all.

For cross validation of measured precipitation satellite TRMM (The Tropical Rainfall Measuring Mission) data files (are nearly real time data in binary format) from the NASA web site (<ftp://trmmopen.gsfc.nasa.gov/pub/merged/3B42RT>) was investigated. TRMM mainly observe rain structure, rate and distribution in tropical and subtropical region, the data play an important roll for understanding mechanisms of global climate change and monitoring environmental variation. TRMM is the first space mission dedicated to measuring tropical and subtropical rainfall through microwave and visible/infrared sensors, including the first space borne rain radar [16].

2. Verification metrics and Calculation

The WRF–ARW model, version 3.1, was used for simulation. The integration domain covered a roughly 1500 km x1500 km region centered over the south-Caucasus region. Mother Domain overlaps S 300- N 500 and E 300- W 600 territory, with resolution 9 km and two-way nest focused mostly on Georgia and its resolution is 3 km. Forecast was integrated at 0000 UTC 1 April 2015, this month was too rainy this year (25 days >1mm) and synoptic processes developed here varied in wide range. In the present study all runs were initialized with 25-km NCEP GFS Model GRIB data, and integrated 72 h. forecast for each day.

Comparisons are made with the surface observation data 12 h accumulated total precipitation

which unfortunately very pars for this aim. Distribution of stations are given on the picture 1. For each case errors and deviations were estimated for individual observation point on the all model simulated forecast valid time: 15h; 27h; 39h; 51h; 63h; (corresponding to local observation), for any configuration and both domains.

There are a number of ways to quantify the verification of NWP models. In this paper, categorical as well as continuous statistics have been applied. Categorical statistics can be derived from two-dimensional contingency tables. We determine the accuracy of the model to distinguish between rain and no rain by using contingency tables (Table 1).

This two dimensional table that gives the discrete joint sample distribution of forecasts and observations in terms of cell counts. Cell count h is the number of event forecasts that correspond to event observations or the number of hits, cell count f is the number of event forecasts that do not correspond to observed events or the number of false alarms, cell count

m is the number of no-event forecasts corresponding to observed events or the number of misses, and cell count z is the number of no-event forecasts corresponding to no events observed or the number of zeros. The forecast quality for this (2×2) binary situation can be assessed using a large number of different verification measures [17-19].

HR is a categorical forecast score equal to the total number of correct event forecasts (hits) divided by the total number of estimates:

$$HR = \text{correct estimates} / \text{total estimates} = (h + z) / n \quad (1)$$

POD is the fraction of those occasions where the estimation event really occurred:

$$POD = \text{correct rain estimates} / \text{rain observation} = h / (h + m) \quad (2)$$

It ranges from zero to one, where one indicates a perfect forecast. POD is very sensitive to the climatological frequency of the event. It can be

Table 1. Two dimensional contingency table

Forecast/observed	Yes	No	Sum
Yes	Hit (h)	False alarm (f)	Forc. yes (h + f)
No	Miss (m)	Correct non-event (z)	Forc. no (m + z)
Sum	Obs. Yes (h+m)	Obs. No (f+z)	(n=h+f+m+z)

improved by issuing more “yes” forecasts to increase the number of hits. It also ignores FAR.

FAR is equal to the number of false alarms divided by the total number of event forecast:

$$\text{FAR} = \text{false rain estimates} / \text{rain estimates} = f / (h + f) \quad (3)$$

It varies from one to zero, where zero indicates a perfect forecast. It is sensitive to false alarms, but ignores misses. It is also very sensitive to the climatological frequency of the event.

Bias score is equal to rain estimates divided by the rain observations. It can be positive and negative and ranges from zero to infinity. It is an objective measure, which mainly addresses precipitation spatial distribution. A positive bias score shows that the model overestimates the observation values while negative bias score indicates an underestimation over the investigated area.

$$\text{Bias} = \text{rain estimates} / \text{rain observations} = (h + f) / (h + m) \quad (4)$$

Skill score is the relative accuracy of the forecast over some reference forecast. The reference forecast is generally an unskilled forecast such as random chance, persistence defined as the most recent set of observations which implies no change in condition, or climatology. Skill score refers to the increase in accuracy purely due to the “smarts” of the forecast system. There are as many skill scores as there are possible scores and they are usually based on the expression:

$$\text{SS} = (A_{\text{estimated}} - A_{\text{reference}}) / (A_{\text{perfect}} - A_{\text{reference}}) \quad (5)$$

The skill scores generally lie in the range 0 to 1, where the skill score of 1 indicates a forecast better than reference forecast and 0 indicates it is not better than the reference forecast. In this study, we have used the TSS as skill score.

It is computed from:

$$\text{TSS} = (hz - fm) / ((h+m)(f+z)) \quad (6)$$

It ranges from -1 to 1 , where 1 indicates a perfect forecast. This kind of skill score has been used in this study because it is independent of dry or wet regime (Ebert and McBride 1997). Other skill scores, like the Heidke skill score, depend on the current precipitation distribution. In this case, the reference forecast is based on random chance [20-21].

In order to quantify the verification results, continuous statistics have been used. Continuous verification measures comprise mean error (ME), MAE, and root mean square error (RMSE). By using multicategory contingency tables with three different thresholds (>5 mm; from 5 to 20 mm and <20 mm) the accuracy of prediction for each threshold has been determined.

The metrics based on continues statistics such as correlation and RMSE were calculated also for GFS global model. Precipitation simulated with WRF-ARW model mother and nested domains was verified using with all statistical parameters described above.

3. Results and discussions

For each station, observed and model simulated time series were compared and the mentioned statistical parameters were calculated.

On fig. 3a, verification results of global model GFS versus observation from several stations are presented. This metrics varies from station to station, but both of them are not high correlations are below 0.7 and standardized deviations values also near to 1 . So the GFS model scale for simulated precipitation cannot satisfy local prediction needs.

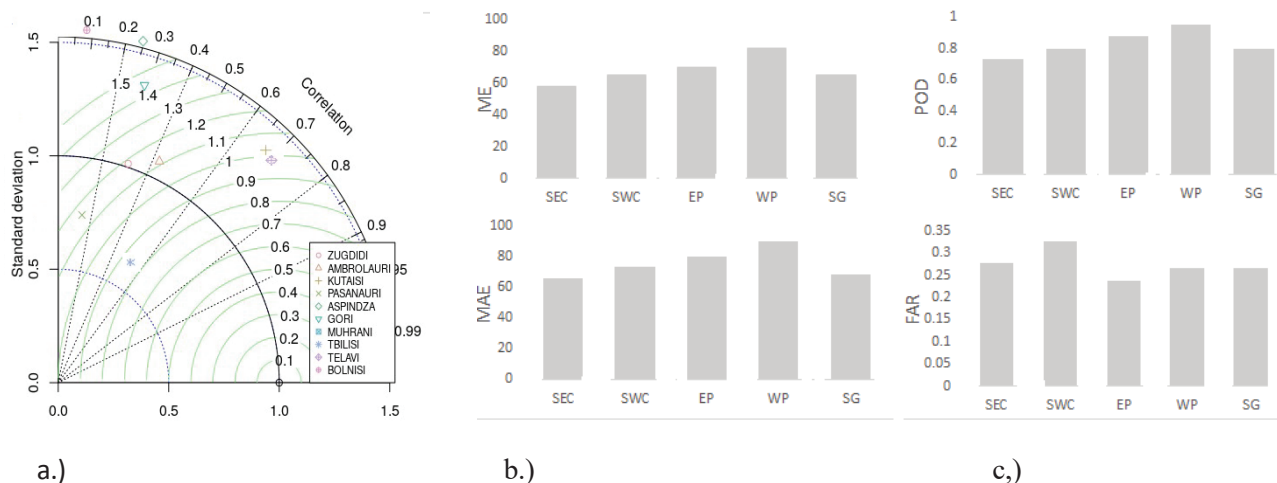


Fig. 2. Taylor Diagram for some stations and GFS (a); ME, and MAE of WRF-ARW precipitation forecast

over 5 subregions in Georgia (b) as well as POD and FAR (for rain/no rain)(c)

Analyzing the obtained results we grouped the stations according to the stations elevation and synoptic processes in the country. Number of subregions in which the metrics have approximately the same range is five: South east of Great Caucasus (SEC), South West Great Caucasus (SWC), Plain of Eastern Georgia (EP), Plain of Western Georgia (WP) and Southern Georgia (SG). This statistical parameters varies from month to month and very depending to thresholds, also. Most of the synoptic processes that take place in the country during the year are caused by the impact of incoming air masses from the Black Sea, which is often accompanied by precipitation in western Georgia.

From the Fig 3 b.) & c.) ME, MAE, POD and FAR indicates better performance in the subdomain WP, which was to be expected. This is also facilitated by the fact that 80% of the daily precipitation in this area is in the range of 5 to 20 mm, and simulating such an amount of precipitation by the model is particularly good, also most of the stations are mainly located in lowland areas, reducing observation distribution errors. (Table 2.)

As it is shown at the table 2 model performance metrics are better for the 12 hour lead time data, for the station as well as satellite observations. In fact, it was expected. Results are better when comparing

model to TRMM than model versus stations. It should be mentioned, that while comparing observed data from satellite to station, deviations are even more than deviation from the forecasted precipitation and station observations. Obtained results might be explained by the different nature of precipitation data, gridded ones from model and satellites and point based observations from surface stations, with quite pares coverage of territory.

4. Conclusion

The results of model validation are not homogeneous inside of domain and are highly dependent on the physical content of the synoptic process. The results are characterized by a certain seasonality. We compare simulation results of some rainy event with several physical schemes configuration and different combination for particular case improves the results, although using this configuration for other processes gives worse results. Which emphasizes that in the future it is desirable to simulate not one configuration of the model, but several simultaneously and generate a multi model ensemble, which also need very long-term and careful validation and verification with additional metrics. In addition, it is necessary to systematically verify all available observational information and allow much longer periods for comparison.

Table 2. Results of comparison of 12 h and 24 h lead time model forecasted precipitation and stations measurement and TRMM

	Mode vs stations (12 h)	Mode vs stations (24 h)	Mode vs. TRMM (12h)	Mode vs. TRMM (12h)
POD	0.781983	0.703396	0.82967	0.761895
Bias	0.278841	0.327582	0.238917	0.266863

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Fungicides from the main diseases of pomegranate in the western zone of Azerbaijan

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ABSTRACT

Diseases of fruit crops cause great harm to horticulture - the yield is significantly reduced and its quality deteriorates, the plants weaken and become susceptible to various adverse conditions, which often leads to their death. Pomegranate scab (*Sphaceloma punicae* Bitank. Et Jenk.) sharply reduces the yield and quality of fruits, zithiasis fruit rot (*Zythia versioniana* Sacc.), which has spread widely in recent years, affects flowers, fruits, stalks, leaves, branches, trunk and root collar, which greatly weakens the tree, reduces its yield and resistance to frost. Damage to fruits by scab or anthracnose in some years reaches 40-50% or more.

A comparative analysis of the field assessment of the biological effectiveness of the applied fungicides in the fight against pomegranate scab in a fruit-bearing garden was carried out. The biological assessment of fungicides was carried out in 2019 and 2020 as already noted in the fruit garden. The study of the preparations was carried out in field conditions, optimal for growing a culture, against a natural infectious background. The plot is homogeneous in fertility, mechanical composition of the soil, relief, planting pattern, crown formation, with the same nutritional area, age and fruiting strength. Trees that were old and damaged by frost, cancers and rodents were excluded.

Keywords: Pomegranate, Main diseases of pomegranate, Phytopathogen, Susceptibility, Control measures, Fungicides.

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Introduction

Subtropical fruit growing is a large branch of agriculture in Azerbaijan, which is represented mainly by citrus fruits (*Citrus* L.), pomegranates (*Punica* L.), olives (*Olea* L.), figs (*Ficus* L.), hazelnuts (*Corylus* L.), nuts (*Juglans* L.), almonds (*Amygdalus* L.), feijoa (*Feijoa* Berg.), pistachios (*Pistacia* L.), etc. Increasing the production of subtropical crops is one of the ways to improve the well-being of the people, improve the supply of food to the population.

Among the subtropical crops, pomegranate is one of the most valuable. The pomegranate is of

exceptional interest for the development of fruit growing in Azerbaijan and Central Asia. However, in comparison with other subtropical crops, the technology of its cultivation, pests and diseases are still poorly understood.

The pomegranate belongs to the Punicaceae Horan. family, which has only one genus *Punica* L., Which includes two species: common pomegranate (*Punica granatum* L.) and Socotran pomegranate (*Punica protopunica* Belf.) [1-5].

Species *Punica protopunica* Belf. (Socotran pomegranate) is endemic to Socotra Island (Indian Ocean), the flora of which is characterized by an abundance of relict species. The Socotran pome-

granate is an evergreen tree and does not represent any economic value.

Species *Punica granatum* L. (common pomegranate) is represented by cultivated and wild-growing forms. Pomegranate in vivo is a small tree or a large bush up to 3-5 m in height, with a curved trunk and a highly branched crown [6].

On the territory of the former Soviet Union, the largest overgrown wild-growing pomegranates are located in the Eastern Transcaucasia. Clumps of wild-growing pomegranate are found in Azerbaijan.

Borders of the natural range of pomegranate: in the east, regions of North-West India and North-East Afghanistan; in the north-south regions of the Central Asian republics, the southern spurs of the Greater Caucasus Range; on the west coast of Asia Minor; on the south coast of the Indian Ocean and its bays [7-10].

Pomegranate (*Punica* L.) is cultivated mainly as a fruit crop, but can also be used for medicinal, technical and ornamental purposes. Its fruits have high taste and medicinal qualities, are distinguished by good keeping quality (up to 4-6 months).

Pomegranate diseases, both abroad and in our country, have not been sufficiently studied. Some diseases of this culture have been studied in Azerbaijan, Crimea, Turkmenistan, Uzbekistan, Turkey, Greece, Georgia, etc. Of the diseases of pomegranate (*Punica* L.), cancer or phomosis (*Phoma punicae* Tassi.), zithiasis fruit rot (*Zythia versioniana* Sacc.) and anthracnose or scab of pomegranate fruits (*Sphaceloma punicae* Bitank. Et Jenk.) are found everywhere.

The purpose and objectives of the research

Azerbaijan is one of the leading areas for subtropical plant growing.

The originality and specificity of the relief, climate, as well as a favorable combination provide the opportunity to grow here subtropical and dry subtropical crops rich in species composition.

Dry subtropical crops are located in five out of ten natural and economic zones of the republic, and in three of them pomegranate (*Punica* L.) occupies an important place as a versatile culture for use.

However, for all the great value of this culture, the diseases that occur on the pomegranate have not been thoroughly studied in the republic until recently, or have been studied fragmentarily, they did not receive due attention. The protection of pomegranates from various diseases in Azerbaijan was carried

out by using multiple applications of various fungicides, which, naturally, contributed to environmental pollution.

In connection with the above, the task of our research was to clarify the species composition of fungi found on pomegranate, to study the biological characteristics of their causative agents of the most harmful diseases in order to develop scientifically based measures to combat the main diseases of pomegranate. In this regard, the following issues were studied:

1. Clarification of the pomegranate mycobiota;
2. Study of distribution, harmfulness, dynamics of development, pathogenicity of pathogens of the most harmful diseases;
3. Revealing the role of agrotechnical and sanitary-hygienic measures in the fight against pomegranate diseases;
4. testing various fungicides and establishing the timing and frequency of treatment and concentrations of fungicides;
5. Establishing the effectiveness of the developed measures.

Research results

Our research work on the study of pomegranate diseases was carried out in the farms of the Goranboy region (Western part of Azerbaijan).

In the western part of Azerbaijan (Ganja-Kazakh zone), the most common and harmful on pomegranate are zithiasis fruit rot (*Zythia versioniana* Sacc.), *Aspergillus* fruit rot (*Aspergillus niger* Van Tieghem.), anthracnose or pomegranate fruit scab (*Sphaceloma punicae* Bitank. Et Jenk.), botrytosis or gray rot (*Botrytis cinerea* Pers.), *Alternaria* or black rot (*Alternaria* sp.), cercosporosis (*Cercospora lythracearum* Heald. Wolf.), cancer or phomosis (*Phoma punicae* Tassi.), late blight or stem rot (*Phytophthora* sp.) macrofomosis (*Macrophoma granati* Berl. Et Vogl.), nematosporosis (*Nematospora coryli* Pegl.), etc [11-14].

Based on the results of 3-year surveys 2018-2020. of fruit-growing farms of the republic, it was found that in the structure of the dominance of phytopathogenic microorganisms in young intensive plantings of pomegranate in terms of frequency of occurrence, the dominant species are pathogens of pomegranate scab (*Sphaceloma punicae* Bitank. Et Jenk.), zithiosis (*Zythia versioniana* Sacc.). The aim of the research was to identify the most common diseases in young industrial plantings of pomegran-



Fig. 1. *Ovary anthracnose*



Fig. 2. *Anthracnose or pomegranate scab*

ate, to establish their species composition.

Anthracnose or pomegranate scab (*Sphaceloma punicae* Bitank. Et Jenk.) is the most harmful disease. Scab is found everywhere in the republic and cause great damage to farms cultivating the pomegranate culture. The disease is poorly understood.

In the conditions of Azerbaijan, the *Sphaceloma punicae* Bitank. Et Jenk. fungus infects the calyx of flowers and the skin of the fruit. A dark brown spot first appears on affected flowers, calyx and fruit. With the further development of the disease, the spots merge, take on various shapes and sizes. Affected flowers dry out (Pic. 1,2).

In places of spots, the development of tissue is suspended, and the surface of the skin is cracked. Cracks also capture healthy tissue, cracking of the entire fruit occurs, which reduces the market value of the fruit. Such fruits are susceptible to other diseases as well.

The source of infection is mummified fruits, fallen leaves and ovaries, as well as infected trees.

To establish the prevalence of scab in the regions of the republic, route surveys were carried out in Shamkir, Geranboy and Kazakh regions. As a result of surveys, it was revealed that pomegranate scab is found in all regions of the western part of Azerbaijan.

Table 1. *Distribution and development of anthracnose or pomegranate scab in the Ganja-Kazakh zone (2018)*

№	Districts	Posting date	Anthracnose or pomegranate scab	
			Spread, %	Intensity, %
1	Goranboy	7.IX	63,2	37,8
2	Shamkir	10.IX	57,2	32,1
3	Kazakh	11.IX	56,5	31,2
	Total	-	58,9	33,7

In addition to yield losses, scab also negatively affects the quality of the fruit. To clarify the effect of the disease on the quality of the fruit, we carried

out analyzes for the content of monosaccharides, disaccharides, ascorbic acid and total acidity in sick and healthy pomegranate fruits.

Table 2. *The content of sugars, ascorbic acid and total acidity in healthy and scabbed pomegranate fruits (2020)*

№	Condition of the fruit	The amount of monosaccharides, %	The amount of disaccharides, %	Acidity, in %	Ascorbic acid, %
1	Healthy	5,2	6,4	3,3	7,4
2	Sick	4,6	6,2	9,2	3,5

The results of our analyzes show that in sick pomegranate fruits, the content of mono- and disaccharides decreases by 0.6-0.2%, ascorbic acid by 3.9%, and the total acidity, on the contrary, increases by 5.9%.

All this is evidence that anthracnose or pomegranate scab (*Sphaceloma punicae* Bitank. et Jenk.) significantly impairs the quality of the fruit.

The most effective, fastest, and most often the only method of preventing and protecting plants from scab (pathogen *Sphaceloma punicae* Bitank. Et Jenk.) is chemical protection.

The chemical method is currently one of the important measures in the fight against pests, diseases and weeds of fruit and berry crops, as it has some advantages over other methods. This method is especially effective when pests are spread over large areas and has a quick effect. However, it has a num-

ber of disadvantages: the danger of pollution of the environment and plant products. Therefore, chemical protection must be accompanied by strict sanitary and hygienic control. Treatment of plants with pesticides should be carried out in accordance with the regulations for their use, taking into account the phytosanitary state of fruit and berry crops [15-17].

The treated plants and the resulting products should not contain residual amounts of the active substance of pesticides above the maximum permissible levels. Therefore, the use of each drug is governed by a waiting period in days from the last treatment to harvest [18-20].

Obtaining high and stable yields in perennial agroecosis of fruit crops is impossible without the use of modern plant protection products, both biological and chemical in nature [21].

Table 3. *Influence of fungicides on the spread and development of anthracnose or pomegranate scab (2019)*

Preparations and their concentrations	First option			Second option		
	After the third spraying			After the third spraying		
	Disease spread, %	Development intensity, %	Technical efficiency in comparison with control, %	Disease spread, %	Development intensity, %	Technical efficiency in comparison with control, %
Azoxifen	34,5	21,1	43,5	38,1	20,9	36,6
Conazol	20,2	11,6	65,2	28,7	13,3	53,1
Selphat	19,0	10,2	68,6	20,1	12,4	66,3
P-oxyride	19,5	11,5	50,9	20,8	12,9	44,5
Control (without chemical treatment)	63,3	37,5	0	62,4	35,3	0

Spraying was carried out in 3 terms in two variants.

In the first variant, the first spraying was carried out 3-4 weeks after flowering before the disease appeared on the fruits.

The second spray, when the fruits reached 1/3 or half of their size, and the third spray 30 days before harvest.

In the second variant, the first spraying was carried out when the first signs of the disease appeared on the fruits; the second spraying at 30 day intervals, the third 30 days before harvest (Table 3).

As can be seen from the table 3, in 2019, in the first variant, the best result against anthracnose or pomegranate scab was obtained in the case of 0,4% Selphate. The spread of the disease was 20,2%, under control 63,3%, development 11,6%, under control 37,5%.

Good results were also obtained in the variant where spraying was carried out with 0,05% Conazol.

The rest of the fungicides tested by us lag behind the standard.

In the second option, the effectiveness of fungicides is the same as in the first option. Selfat turned out to be the best, followed by Conazol.

Conclusion

On the basis of our studies, it has been established that fungal diseases (especially anthracnose or pomegranate scab), common in Azerbaijan, cause great damage to pomegranate plantations.

In the fight against pomegranate diseases (including scab), both sanitary and hygienic, agrotechnical and chemical measures are significant. It has been established that the applied fungicides are effective against the complex phytopathogens of pomegranate (especially against *Sphaceloma punicae* Bitank. Et Jenk.). Spraying the pomegranate with 1% Bordeaux liquid and other preparations replacing it during the budding period, after the first petals fall and 15-20 days after the second. Four to five spraying of adult pomegranate plantations at the first signs of anthracnose or pomegranate scab 0.05% Azoxifen, 0.05% Conazol, 0.4% Selfat, 0.3% P-oxiride: first, before bud break (after trimming and cleaning the trunks and skeletal branches from peeled bark, mosses and lichens); the second, after the first petals have fallen; the third, 20 days after the second; fourth, when the fruits reach large sizes; fifth - (if necessary) - 15-20 days after the fourth.

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Debris flow density and their effect on debris flow regulation buildings

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ABSTRACT

The regulation of debris flow, the issue of their energy dissipation, the selection of calculation models and the design of regulatory measures are related to the selection of the elements that determine the interaction with the flow of anti-flood buildings. In this scientific paper, innovative methods are used to determine and evaluate the criteria of debris flow behaviour at the point of origin, evaluating energetical specifications, and determining its density/bulk. In conjunction with rheology, we can determine energetic characteristics (of a debris flow) and for regulatory purposes, new regulatory constructions are being processed. Great attention should be paid to the latest debris flow regulatory elastic barrage which we received copyright and patent for. The project parameters have been calculated, for example, determining the required number of computational dependencies of the flow striking force acting on them in the plan.

Keywords: Debris flow, Density bulk, Natural anomalies, Landslide regulation, Pronounced zone, Flow structure.

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Introduction

Natural anomalies and their impact on the environment is very important, and the risks they pose, to effectively use natural resources and advance the economy.

Based on the analysis of the existing debris flow control measures, the environmental condition still fails to meet the high risks of natural infrastructure. Priority is given to the creation of new forms of innovative countermeasures, as well as the improvement of the calculation methodology. This is due to the genesis and dynamics of Debris flows, as well as the complexity of designing buildings.

Main Part

The study, which deals with the problems of landslide regulation, is focused on refining the meth-

odology for calculating regulatory measures and perfecting the full redistribution of the impact force of the flow on the pressure surface of the building. The study also discusses the possibilities of changing the flow modes and density caused by the complexity of the bed shape on the transit sections of the floodplains. Especially the issue of flood regulation and the critical impact on buildings should be taken into account in sections of the pipeline where they have a pronounced complexity of the shape of the transverse section, so the duct experiences a change in the size of the flow it either expands or contracts according to the flow direction; also the density of the flow is changed. Assessing the impact of flow on the obstacles encountered under such conditions and selecting regulatory measures are associated with completely different approaches and the selection of calculation methodologies [1-3].

An analysis of the causes, of the loss, of the existing debris flow regulatory structures, confirms that the cases of failure of each of them are considerably different from each other. When selecting a model for the impact of flow on buildings, it is necessary to specify the main factors determining the durability of the building along with the issue of energy dissipation, and the layout, quantity and dimensions of the building plan should be based on these factors [4-8].

Approaches to assessment of debrisflow behaviour, sustainability, change in energy performance and methods and methodology for the assessment of criterion indicators are given in scientific papers [9-13].

Based on the methods and methodology for assessing Debris flow behavior, resilience, changes in energy characteristics, and criterion parameters, when Debris flow acceleration is recorded over a short period of time, its magnitude is not related to body deformation and is estimated by impact force and accuracy of deformation [14].

When evaluating stability, analogues of Debris flow deformation within the proportionality limits can be used when the magnitude of the tensile-compression velocity model is less than or equal to the similar magnitude of the sound propagation. n the

case of a complete evaluation of the process, the possibility of disruption of the flow structure and the expected cessation of mass are taken into account during the impact.

The possibility of creating a pronounced zone of disturbance during a blow is due to the rate of deformation and at the same time depends on the concentration of tension, the shape and size of the striking flow. When studying the impact of Debris flows on oncoming obstacles, the paper discusses a case where both the potential and kinetic energies of the Debris flow in action are known. The possibilities of equal energy between tension and deformation are preserved. The connection between them is linear. The values of the deformation under dynamic and static impact are equal to each other, for example in the case of a transition to the kinetic energy to potential energy; the values of the deformation are equal to each other.

Disruption of flood resistance, the formation of free surface shape, continuous or gradual change of hydraulic elements, is caused by the influence of many interrelated factors.

The model of a rolling mound in a long cylindrical flow bed having the shape of a rectangular cross-section in the form of a calculation scheme is given in the first scheme.

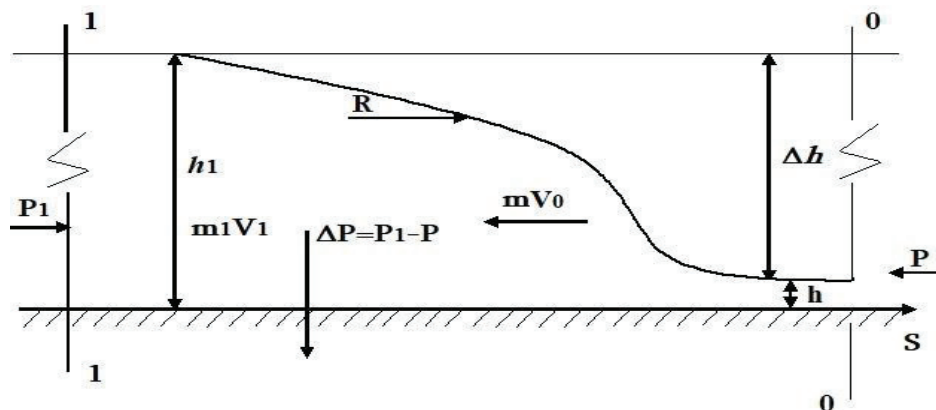


Fig. 1. Longitudinal cross-section of debris flow wave

Under the influence of rheological characteristics, an analytical relation is established between the debris flow wave characteristic and the force pulse based on the given scheme. From section 1-1 the mass $m_1 = \rho Q$ does not change in the direction of the wave, and therefore, when the velocity is equal to V_1 , the amount of motion is represented by the magnitude $\alpha V_1 \rho Q$, and the sum of the amount of flow motion has a force dimension. Similarly to the cross-section of 1-1, in cross-section 0-0 if the wave

propagates at a velocity of V_0 , the amount of flow motion will be $\alpha V_0 \rho Q$. Costs represented by such assumptions have a dimension of force, and the magnitude of their projections, when the S-axis has an anti-displacement direction, can be negatively represented.

When the depth h_1 of the Debris flow mass decreases to a depth h , the magnitude of the flow in the control sections is equal to Q , and the change in force from P to P_1 occurs as an impulse, the equation

of the balance of the number of seconds motion will be as follows:

$$\rho QV - \alpha \rho QV_0 = P_1 - P \quad (1)$$

In the selected sections, when the volumetric weight of the trough, the width of the transverse section B, and the change in momentum of the force are equal to ΔP , Equation (1) can be represented as follows:

$$\frac{\rho Q}{g} \frac{B}{\Delta P} = \frac{h_1 h}{h_1 - h} \quad (2)$$

In the case of debrisflow in the form of a wave corresponds to the non-stationary nature of the flow motion. In the case of wave motion in the form of a wave corresponds to the non-instability of the flow motion.

When determining the energy characteristics of a flood in the transit section of a duct, when the free surface has the face given in the diagram (Fig. 1), the magnitude of the pressure loss can be represented by a differential equation.

$$\frac{dh}{d\ell} = \frac{i_c \frac{Q^2}{a^4 \omega^2 c^2 h} \left(1 - \frac{\alpha \alpha c^2 h \partial \omega}{g \omega \partial \ell} \right)}{1 - \frac{\alpha Q^2 B}{g a^3 \omega^3}} \quad (3)$$

Where i is the slope of the duct;

Q - flood consumption;

ω - cross-section area;

α - coefficient of rheology;

c - speed resistance coefficient;

μ - viscosity coefficient;

g - gravity force acceleration;

h - depth of flow.

When a torrent moves at a variable flow rate (Q) and its specific magnitude from the 1 longitudinal meter of the channel is equal to

$$q = \frac{Q}{\ell}$$

$$\frac{dh}{d\ell} = \frac{i_c - \frac{QV}{gBf(\beta)} \left(1 - \frac{ghf(\beta)}{2K^3 B} \right)}{1 - \frac{\alpha Q^2 B}{ga^3 \omega^3}} \quad (4)$$

To simplify the calculation of the f-s and the values of the members of differential equations (3) and (4) fig. 3 and fig. 4 – Dependency

$$f(\beta) = \frac{h_0}{2h} \left[\left(\frac{h_0}{h} \right)^2 - 1 + \frac{1}{3} \left(1 - \frac{h_0}{h} \right)^3 \right], \alpha' = f(\varphi) \text{ and}$$

$$\alpha'' = f\left(\frac{h_0}{h}\right); \text{ a graphs are given.}$$

In the case of motion in the form of a longitudinal wave of a debrisflow, when the change of its hydraulic elements is slow, the velocity of the wave propagation is 3 times higher than the average velocity [15, 16].

The binding mass is characterized by the ability to resist external stresses whose shape change is completely different from that of Newtonian liquids. The change in the shape of the torrent body is related to the possibility of impact resistance and the tense state of the flow.

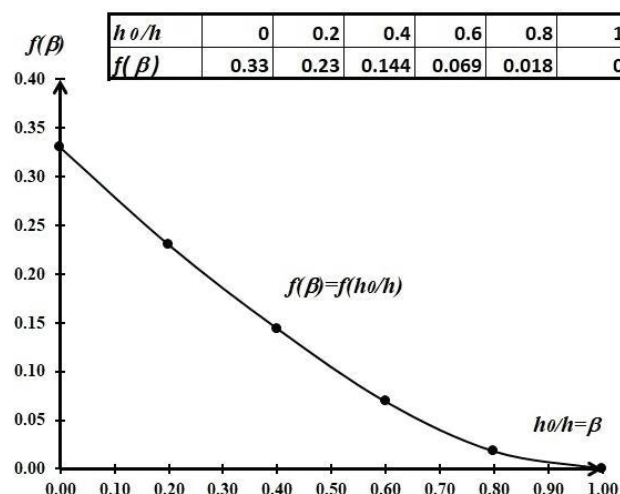


Fig. 2. Graphical Dependency $f(\beta) = f(h_0/h)$

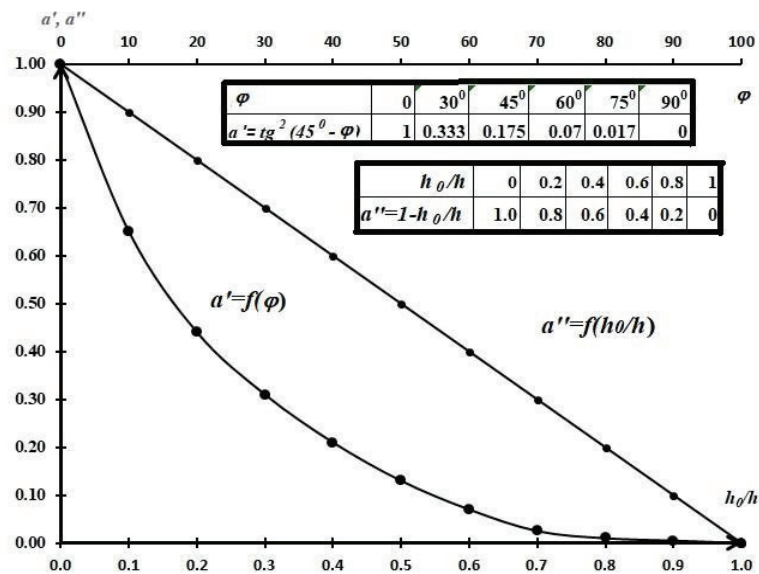


Fig. 3. Graphical Dependency $a' = f(\varphi)$ and $a'' = f(h_0/h)$

Gradual, leapfrog, and gentle changes in the dynamic characteristics of the flow are expected when overcoming the obstacles encountered in the duct by a torrent. The classical approaches in the form of Lagrange dependencies are widely used in estimating the dynamic velocity wave (V_0) in the duct. Based on the analysis of the differential equations (1) and (2), when the magnitude $1 - \frac{\alpha Q^2}{g} \cdot \frac{\omega^3}{B\alpha^3}$ of the right-hand

side is equal to 0, the cross-sectional energy is minimal in magnitude and the wave propagation velocity C is equal to the average velocity $\bar{V}$. Based on continuous wave studies, in the case of a constant flow forward flow rate, the characteristics can be used to estimate the contact wave velocity, duct mode regimes, and pressure changes in the duct. In particular, in the case of a change in pressure - the flow velocity, and in the case of a disturbance characteristic - the elasticity parameters of the change in mass and volume [15-17].

The risks of floods and the impact on oncoming obstacles are related to the perfection of the methods of correct assessment of the criteria defining the movement and stopping capacity of their formation.

Particular attention is paid to cases of impacts on flood resistance, which are associated with the prediction of changes in its structure, concerns with the flow resistance in the body, changes in the geometry of the flow body, and the shape of the free surface obtained during stopping. Each specific task, depending on the above, depends on the types of floods and each case of energy extinction is due

to the cases of effective deployment of regulatory measures.

In the case of the well-known morphometry of the duct, the possibility of breaking the structure of the moving flow is possible with points located on its free surface. The flow maintains a continuous appearance of the free surface without hydraulic jump when the bottom is turned. In the event that the duct slopes are less than critical and when this condition is violated, its stability is lost. There is a free surface crossing of the critical and the generation of a wave [9,15,17].

Stability forecasting and estimation of regime change is possible only when the shape of the free surface of the flow motion is known. Representing the flow in this way and constructing its free surface circle is possible by selecting the length of the small section of the pipeline, using hydraulic dependencies, compiling the differential equation of motion, simplifying it for convenience of integrations, calculating free surface coordinates based on the equation and building the surface profile.

When assessing debris flow resilience it is necessary to consider the role of the influence of oncoming resistances in the regularity of the change in flow stability, along with the possibilities of changing the flow dynamics and the stress state.

By changing, narrowing or expanding the deformation of the Debris flow mass, it changes the shape of its body, as well as the electromagnetic and thermal state. At the same time, there is a transition of spent energy into potential and the formation of a

free surface flow in the form of a wave.

The lateral expansion of a semi-unloaded debris flow is estimated by lateral expansion coefficient. When the Debris flow mass is bounded by a horizontal surface and the stress element is characterized by height h , volumetric mass γ , angle φ of internal friction, equivalent depth of bond h_0 , the lateral expansion change picture can be estimated based on the relative magnitude of the main stresses or the lateral expansion coefficient.

$$\frac{\sigma_2}{\sigma_1} = \frac{\gamma h \left(1 - \frac{h_0}{h}\right) \tan^2 \left(45^\circ - \frac{\varphi}{2}\right)}{\gamma h} = \left(1 - \frac{h_0}{h}\right) f = \frac{\mu^*}{1 - \mu^*} \quad (5)$$

The magnitude of the relative deformation coefficient of the Debris flow mass, when the amplitude of the Debris flow mass is B , the height is h , and the

corresponding values of the deformations are equal to ΔB and Δh ,

$$\mu^* = \frac{\frac{\Delta B}{B}}{\frac{\Delta h}{h}} = \frac{\left(1 - \frac{h_0}{h}\right) f}{1 + \left(1 - \frac{h_0}{h}\right) f} = \frac{\alpha}{1 + \alpha} \quad (6)$$

According to the 6th dependence analysis, the magnitude of the relative deformation is a function of the rheological characteristics and a clear picture of its change is presented in Figure #4. Reducing the flow width corresponds to increasing its depth and breaking the parallelism of the flow cycles. When the width of the flood is equal to B and the lateral narrowing is equal to ΔB , the value of the width bounded by the narrowing of the width $B_{mar.}$ is equal to $B - \Delta B \leq B_{mar.}$ (7)

The magnitude of the lateral deformation of the flow width $\frac{\Delta B}{B} = 1 - \frac{B_{mar.}}{B}$ (8)

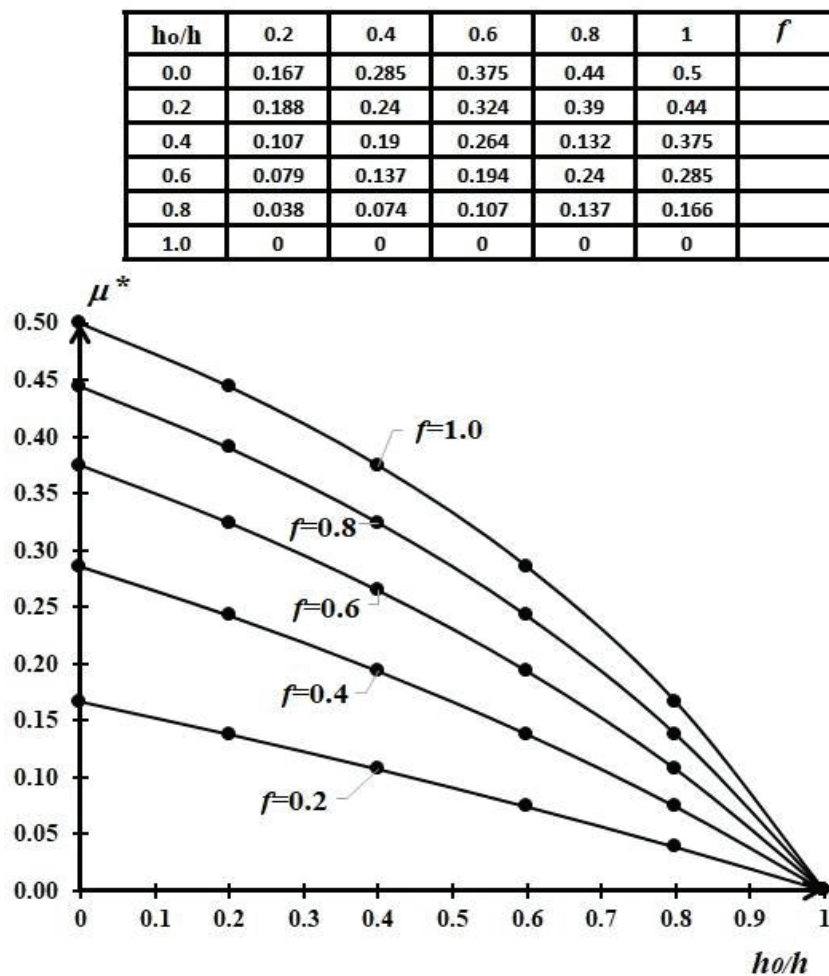


Fig. 4. Graph of the relation of the relative deformation to the rheological characteristics of the flood

Ability to increase the height of the flooding mass caused by lateral constriction $h_1 = \Delta h + h$ (9)

The magnitude of the cross-sectional contraction of the flow from the (6) dependence

$$\frac{\Delta B}{B} = \mu \frac{\Delta h}{h} = \frac{\alpha}{1+\alpha} \cdot \frac{\Delta h}{h} \quad (10)$$

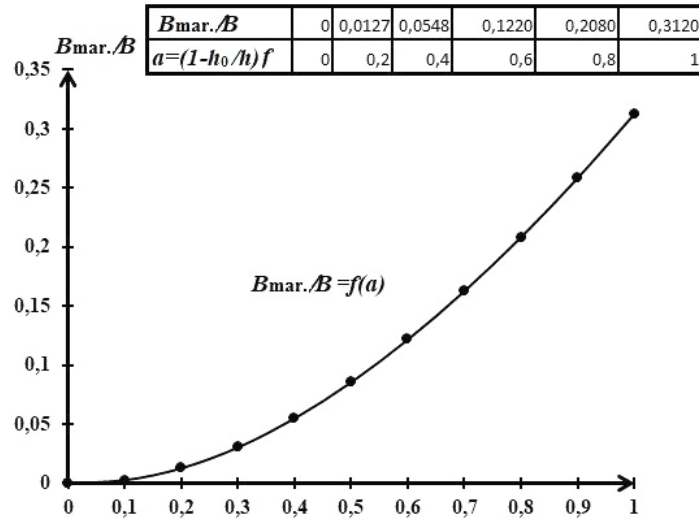


Fig. 5. $B_{mar.}/B=f(a)$ Dependency Graph

If we consider the case of dam rupture or core collapse as a model of a stopped wave of displacement of the Debris flow mass, based on the magnitude of the flow q resulting from the deformation in such a case and the value in decreasing the fall velocity in case of changes in Debris flow height from h_1 to h . $V = 2\sqrt{gh_1} - 2\sqrt{gh}$. (11)

Debrisflow energy expenditure

$$q = h(2\sqrt{gh_1} - 2\sqrt{gh}) \quad (12)$$

According to the analysis, the minimum magnitude of the Debris flow cross-sectional energy corresponds to the condition when the ratio of the average kinetic energy to the potential is equal to 1, respectively, based on Equations (1) and (2).

$$\frac{dh}{d\ell} = \infty \quad 1 - \frac{\alpha Q^2}{g} \cdot \frac{B}{\alpha^3 \omega^3} = 0$$

When $\omega = 1$, flow $Q = \omega V$, mean flow velocity is equal to wave velocity,

$$C = V = \left(1 - \frac{h_0}{h}\right) f C \sqrt{\left(1 - \frac{h_0}{h}\right) f g h} = C \alpha \sqrt{\alpha g h} \quad (13)$$

The relationship of the magnitude of the transverse contraction of the flow to the rheological characteristics is given fig. 5.

Accordingly debrisflow energy expenditure

$$q = \alpha h \sqrt{\alpha g h} \quad (14)$$

Based on the result obtained above,

$$h(-2\sqrt{gh} + 2\sqrt{gh_1}) = \alpha h \sqrt{\alpha g h} \quad (15)$$

Accordingly the magnitude of the deformation

(16) Considering this in (9)

$$\frac{\Delta h}{h} = \frac{\alpha^3 + 4\alpha\sqrt{\alpha}}{4} \quad (16)$$

$$\frac{B_{mar.}}{B} = \mu * \frac{\alpha^3 + 4\alpha\sqrt{\alpha}}{4} = \frac{\alpha}{\alpha+1} \cdot \frac{\alpha^3 + 4\alpha\sqrt{\alpha}}{4(\alpha+1)} \quad (17)$$

The magnitude of the relative deformation with respect to (10)

$$\frac{\Delta B}{B} = 1 - \frac{\alpha}{\alpha+1} \cdot \frac{\alpha^3 + 4\alpha\sqrt{\alpha}}{4} = \frac{4(\alpha+1) - \alpha(\alpha^3 + 4\alpha\sqrt{\alpha})}{4(\alpha+1)} \quad (18)$$

When the rheological characteristics do not affect the deformation e.g. $h_0 = 0$ and $\alpha = 1$, respectively, $\frac{\Delta B}{B} = 0,375$ and the obtained result fully confirms the results of the research [14].

The magnitude of the relative elongation of the stretch by contraction and lateral constriction of the debris flow mass

$$\frac{\Delta h}{h} = \frac{h_1 - h}{h} = \frac{h_1}{h} - 1 \quad (19)$$

Accordingly (16) - in (19)

$$\frac{h_1}{h} = \frac{4\alpha + \alpha^3 + 4\alpha\sqrt{\alpha}}{4}$$

When $\alpha = 1$, $\frac{h_1}{h} = 2,25$. The values of the ratio

of longitudinal and transverse deformations of the flow in the control sections if we express the extension or contraction with the initial value. $\frac{h_1}{h} = f(\beta)$

$$f(\beta) = \frac{(\alpha^3 + 4\alpha\sqrt{\alpha})(2 + \sqrt{\alpha})^2}{16} \quad (21)$$

Accordingly the magnitude can be determined $\frac{h_1 - h}{h, h}$ by dependence (21) An illustration of the relative magnitude $\frac{h_1}{h}$ is given in connection with rheology fig. 6.

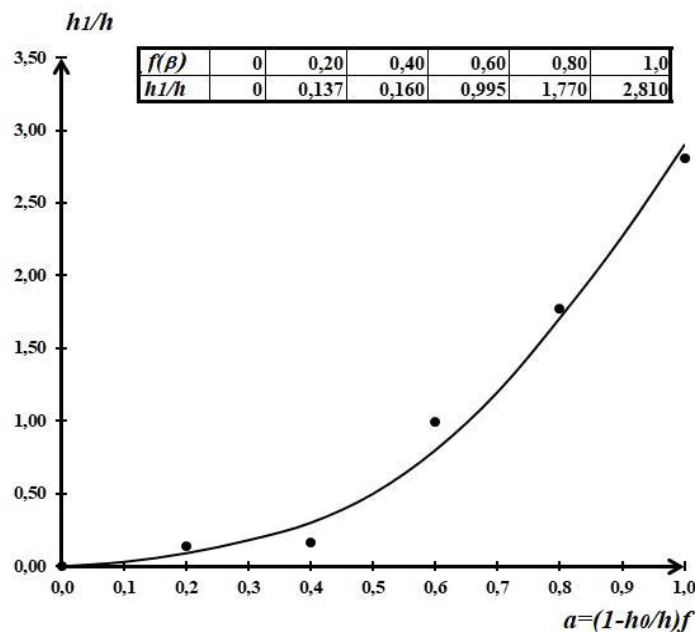


Fig. 6. Graph of h_1/h dependence in relation to debris flow rheological characteristics

Flood risks and impact on various facilities are related to its capacity and energy performance. Among the regulation tasks, it is important to balance the free surface equilibrium of the flow created by the opposing resistances working in dynamic strikes in the flow and the flow-free balance created by the resistance forces. The layout in the engineering action plan is related to the appearance of a flow-free surface and the existence of many such anomalies in nature. The impulse of the dynamic impact of the flood on oncoming resistances.

$$\Delta P = (\rho CV + \rho V^2) \omega \quad (22)$$

When $C \gg V$ -moving debris is equal to $\sin \alpha$

$$\Delta P = \frac{Q\gamma\omega V^2}{g} \sin \alpha \frac{16 - (\alpha^3 + 4\alpha\sqrt{\alpha})(2 + \sqrt{\alpha})^2}{(\alpha^3 + 4\alpha\sqrt{\alpha})(2 + \sqrt{\alpha})^2} \quad (23)$$

In Equation (23) because hence the value of the striking coefficient: $f(\alpha) = (\alpha^3 + 4\alpha\sqrt{\alpha})(2 + \sqrt{\alpha})^2$,

$$m = \frac{16 - f(\alpha)}{f(\alpha)} \quad (24)$$

The magnitude of the impact force of the Debris flow/debrisflow

$$P = m \frac{\alpha \omega V^2}{g} \sin \alpha \quad (25)$$

As the dependence analysis (22) confirms, the magnitude of the functionally striking force coefficient is related to the rheology of the Debris flow and the nature of its change depends on the face of each particular Debris flow. When a value of $\alpha > 0.60$ in such a case corresponds to the condition of the immobility of the Debris flow and the probability of impact resistance is equal to 0. Function 1 is equal to the case when $\alpha = \left(1 - \frac{h_0}{h}\right) \cdot f$

The value of the impact force coefficient is a function of the rheological characteristics and its

magnitude is given graphically in Fig.7.

Flood-regulating measures in the environment according to the purpose, according to the con-

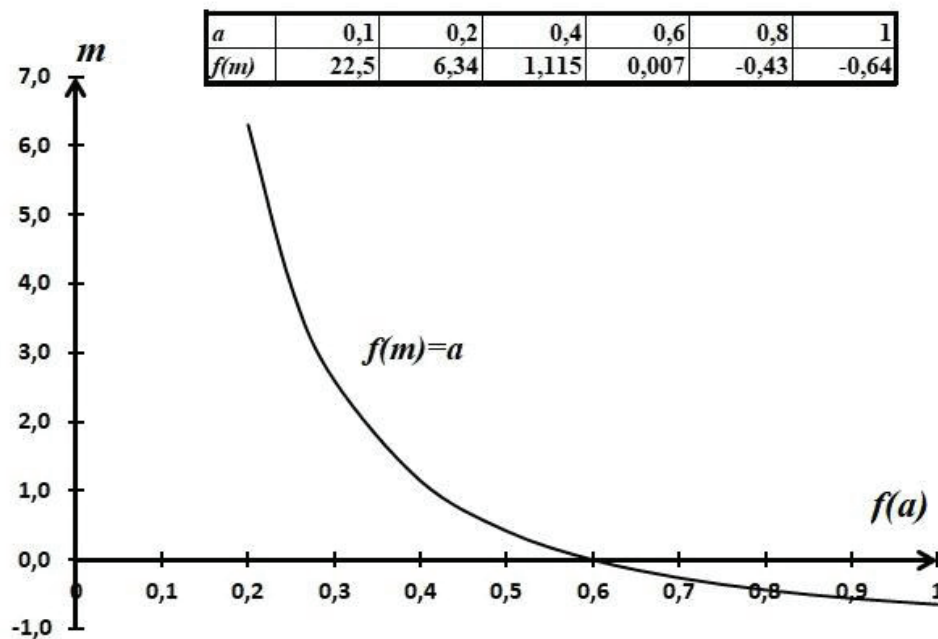


Fig. 7. Graph Dependency $m = f[f(a)]$

structive solutions of the constituent elements, are divided into flood-transit, flood-management and debris flow buildings. The function of each of them is diametrically different from each other and the possibilities of failure are caused by the specificity of the impact of the floods. Based on the above, the paper presents an innovation compared to the existing flood control by changing the direction of the strategy of application of regulatory measures and the longitudinal change of structural solutions of transverse structures. In this regard, the types of buildings on which copyright certificates have been obtained have been processed. The patent for the recently created elastic barrier stands out (P20207068B) – invention [18-26].

The effect of impact on floodplains is related to their permeability when regulated by copyrighted buildings. According to the permeability coefficient and the types of buildings, the strong impact of floods according to the types of buildings is given in the form of calculation dependence:

1. Semi-conical permeable structure;

$$\Delta P = \frac{\alpha \omega V^2}{g} \sin \alpha \left[\left(0,215 + 0,785 \left(1 - \frac{h_0}{h} \right) \right)^2 \right] \frac{16 - f(\alpha)}{f(\alpha)}; \quad (26)$$

2. Pyramidal permeable structure;

$$\Delta P = \frac{\alpha \omega V^2}{g} \sin \alpha \left[\left(0,5 + 0,5 \left(1 - \frac{h_0}{h} \right) \right)^2 \right] \frac{16 - f(\alpha)}{f(\alpha)} \quad (27)$$

3. Semi-cylindrical building;

$$\Delta P = \frac{\alpha \omega V^2}{g} \sin \alpha \left(0,5 - 0,5 \frac{d}{H} \right) \frac{16 - f(\alpha)}{f(\alpha)}; \quad (28)$$

4. Flood regulating elastic barrier

$$\Delta P = \frac{\alpha \omega V^2}{g} \sin \alpha \frac{1}{\left(1 + \frac{d}{H} \right)^2} \cdot \frac{16 - f(\alpha)}{f(\alpha)} \quad (29)$$

In the case of a prismatic intersecting channel, when the volumetric volume of the flood and the velocity correction coefficient are represented by a , the velocity of the flow motion is V , the velocity of the wave propagation on the flow surface is C , and the magnitude of the impact of the momentum P is on the opposing resistances. S equals, breaking the condition of sustainability and its loss can be expressed by inequality:

$$V_0 \geq V + C \quad (30)$$

In Equation (30), taking into account the values of V and C , with respect to the corresponding transformations and simplifications, the flood resistance in the case of its slope is equal to:

$$i \leq 0,00067 \sqrt[3]{\frac{d}{h}} \cdot \frac{1}{\alpha^2} \quad (31)$$

When the magnitude of the slope of the Debris flow is known, the distance between the Debris flow elastic dams in the case of the L -balancing I slope

$$L = \frac{H}{I} \cdot \frac{\alpha^2}{\alpha^2 I - 0,00067} \quad (32)$$

Table. The report of the member (a) included in the formula

$\frac{h_0}{h} \backslash f$	0	0,4	0,6	0,8	1,0
0	0,04	0,16	0,36	0,64	1,0
0,2	0,0256	0,102	0,234	0,409	0,64
0,4	0,0144	0,0576	0,1296	0,264	0,36
0,6	0,0064	0,0258	0,00576	0,1024	0,16
0,8	0,0016	0,0064	0,0144	0,0254	0,04
1.0	0	0	0	0	0

Conclusion

Based on the analysis of the impact of debris flows on the existing debris flow regulation facilities and based on the selection of regulatory measures, innovative construction solutions are presented to the debris flow regulation building and a new methodology for their calculation is proposed;

Based on the dynamics of floods, the potential for their reliability/strength is assessed, and innovative reporting models are adapted to the event to clarify the criteria for determining reliability/strength. Based on the use of the corresponding inequality in the definition of reliability/strength, the possible conditions of reliability/strength are specified;

According to the theoretical characteristics, the strain mass and deformation possibilities are evaluated;

An innovative model for the impact on flood defences is proposed, based on which the calculation ratios of the impact force are derived taking into account in the types of buildings;

Different design strategies are used in terms of flood risk neutralization, building design solutions, rigidity and regulatory potential. Innovative methods and methodology are used to derive the calculation dependencies of the striking force of the flow, the loss of stability, the determination of the distance between buildings.

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Ecology and sustainable development. New model of economics

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ABSTRACT

The existing economy and its infrastructure is built mainly as a liberal, costly market system, whose main function is to make a profit. In this case, it is necessary to organize a system for the delivery, storage and distribution to the places of consumption of huge quantities of goods and resources. Such a costly model carries a large amount of transaction costs for transport, transshipment, storage, payment of numerous intermediaries, infrastructure operators and various financial agents. Today, the current economy of rampant growth is changing to a low-cost, actively-adaptive intellectual (Smart) “green digital economy” based on digital information technologies, which is the basis for sustainable development. as the basis for maintaining environmental, socio-economic and political stability in the world community within Fourth Industrial Revolution Economy. A new model of the world economy should be a circular economy, which, based on energy and resource-saving low-volume technologies and network digital platform solutions, will ensure sustainable development, taking into account all environmental principles of environmental protection.

Keywords: Ecology, Sustainable development, Digital economy, Energy, Smart systems, Ring economy.

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Introduction

What is Economics? Many people ask themselves this sacramental question today. Seems to be clear. It is a complex system designed to produce various life-supporting goods and services from natural resources for the population. However, if you think about it, it's not that simple. Note that in today's market capitalist mode of production, the target function of production is not profit for people, but profit. The basis of this way of organizing the economy is, as Adam Smith wrote, not the benevolence of the producer, but the observance of their own interests, that is, self-interest. That is, what does not make a profit, it makes no sense to do this, because the main indicator is profit-money. Aristotle also spoke of two different ways of managing. One is chrematistics-profit associated with making a profit, the second is Economics - (from gr. οἶκος – home and νόμος - to rule), services for people's homes. From this first Greek word comes the term ecology-the science of our common home of the

natural environment. In this regard, it is of interest how to ensure sustainable development of territories in the conditions of the resource crisis caused by the existing situation in the world economy, operating on the linear principle of resource extraction-sold - used-thrown away, sent to the landfill. At the same time, the more resources spent, produced, sold, and thrown away, the better, since the greater the profit. And the fact that this scheme is energy and resource – consuming and generates a huge amount of waste-garbage, this is of little concern to the participants of economic activity, especially since the disposal of useless, often usable things, brings, as experience shows, a huge profit. So the main appeal to consumers is to Buy and consume, even if it doesn't make any sense.

Main part

The environment surrounding a person is a natural ecosystem, outside of which he cannot live, since it is initially an inseparable part of its biocenosis.

We must understand that man is not a conqueror of nature, but a part of it, built into natural cycles, as an element that should not destroy or plunder resources, but uses them as a commodity credit that must be returned. We need to realize this and build our economy in accordance with this principle. However, the intensive development of the world economy in the last century has come into conflict with these principles and created a huge burden on the natural environment and its resources. It should be noted that globalization and related crisis phenomena are derived from the modern civilizational model, which is based on unrestrained consumption. Under these conditions, the anthropogenic load on the environment exceeded all permissible limits. As a result, it can degrade and become unsuitable for further providing the growing population of the Earth with the resources necessary to support human life.

The existing economy and its infrastructure, and not only, is built mainly as a liberal vertically integrated centralized cost-based market system, the purpose of which is to make a profit. Production of goods is organized as follows: it is necessary to get resources and competencies, deliver them to specialized centers, process them there, get the product, and then use the infrastructure to deliver it to the consumer, who can sometimes be thousands of kilometers away from the place of production. At the same time, it is necessary to organize a system of delivery, storage and distribution of huge quantities of goods and resources to places of consumption. This cost model carries a large amount of transaction costs for transport, transshipment, storage, payment of numerous intermediaries, infrastructure operators and various financial agents. Moreover, this does not create any added value, for it generates a large amount of unsecured profit, creates a fictitious gross product in the form of financial bubbles of unsecured assets that exceed the real world economy in various estimates from 10 to 15 times. This also leads to a huge stratification of the population by income. The main part of the population is poor, and a handful of so-called owners, appropriating the results of labor of workers, get rich.

So: the Global Gross domestic product (GDP) at current prices was in 2019 84,740.32 billion \$ (<https://www.statista.com>), but “behind the average numbers there is a large inequality. More than half of global wealth (50,8%) are in the 1% super-rich, over three-quarters (77,7%) – 5% richest and the 10% wealthiest accumulate 89,1% of global wealth – was about the same proportion and in the begin-

ning of the century, the report says. Wealth in excess of \$50 million (net of debt) have 140 900 people, including 52% of the U.S. and Canada, 21% – Europe 18% – developing countries”. According to Carlos Barria/Reuters: Half of the world’s adult population has only 1% of global wealth. In this issue, Russia is not far behind the global trend, as Olga Kuvshinova wrote in *Vedomosti* on November 23, 2016: 10% of Russians account for almost 90% of the country’s national wealth. Klaus Schwab in Davos in 2019 said that the biggest threat to economic stability is an imbalance in the world (<https://www.businessinsider.com/the-world-economic-forum-founder-shares-the-biggest-threat-to-the-economy-davos-2019-1>).

The results of a market-based liberal economy are often negative. In all post-Soviet States, with the exception of the Baltic States, which are subsidized by the European Union until 2020, the standard of living of the majority of the population has fallen and an interesting class of working beggars has emerged, not to mention pensioners. Another illustrative example is the reform of RAO UES of Russia, which promised to modernize the energy sector and reduce tariffs as a result of declared market and competitive relations. So what? Rampant growth in tariffs, investment at the expense of consumers, increased losses, corruption, and monopolism. For beautiful words about prosperity, the market is cruel and at any opportunity to get more than a profit, there are violations of all written and not written rules and morals.

You should always remember that the main factor of growth in the market system is profit-money, which is in conflict with many moral and aesthetic norms and universal values, since market relations often lead to wasteful attitude to resources. “The more I sell, the more resources I spend, the greater the profit.” This business thesis conflicts with the ideas of saving the environment and sustainable development. The market is good for satisfying private needs, but solving the needs of society is in conflict with the interests of capital. In this regard, we need a self-regulatory mechanism for evaluating efficiency, with appropriate methods of regulation, preferably self-regulation, which should motivate the reduction of resource costs for obtaining goods and services. For market fundamentalism, According to George Soros, is a much greater danger for an open global society than communism. Therefore, the community of free citizens-the “open society” - must control and resolve all problems that arise

in the markets, in the interests of people, since any sustainable development is necessary to ensure comfortable living conditions for current and future generations.

The model of life built by Western civilization sets the goal of unrestrained, sometimes senseless consumption for every person and community. And often the needs that are not necessary for maintaining life arise in the environment of people. And no one can answer the question: Why is this necessary? What was good yesterday is not the same today. Quite decent items that are suitable for consumption go to the landfill or as second-hand to those who do not yet know that these things are no longer suitable for other people living in another dimension. The Western liberal civilized model of behavior and satisfaction of life needs is based on unrestrained, uncontrolled consumption and, often not clear to many, glamorous behavior. This requires the removal from the natural environment of huge amounts of various natural materials, the creation of which humanity has nothing to do, and turning them into hostile to the surrounding world and all living things, including human trash, for the production of which an increasing amount of energy resources is needed. Basically, this is a hydrocarbon fuel that is burned in the furnaces of power plants, motor vehicles, heating systems, and the like.

All this leads to the carbonation of the natural environment, the greenhouse effect, an increase in the global average temperature and, as a result, to global climate change, which leads to numerous climate catastrophes today, with great loss of life and material losses. In 2018, an IPCC (Intergovernmental Panel on Climate Change) report indicated that the planet is about 1.0 °C warmer than pre-industrial levels and is likely to reach 1.5 °C by 2030, and in June 2019, the UN gave a global assessment of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), which States that the rate of animal extinction is accelerating and up to 1 million species are at risk of extinction. Both UN reports indicate that humanity is actually facing a man-made environmental disaster.

The above-mentioned trash is not included in any natural cycles, it is not disposed of by the natural one. It makes the world around us uninhabitable. There are still intact, undisturbed places that are suitable for natural life. There are fewer of them. The life of hotel personalities and their groups has become a pursuit of ghostly values: everything

needs more, more and more. More money, more houses, more yachts, more rags, more cars, and so on. It's not clear why. All this requires increasing amounts of non-renewable material and energy resources, which leads to their depletion, and unrestrained consumption generates a huge amount of waste, which leads to pollution of the natural environment due to the huge amount of waste that is not disposed of by nature. So only: millions of tons of plastic waste are drifting on the surface of the world's oceans, and, according to experts, 80% of this garbage got into the ocean from land and only 20% was dumped or washed away from ships. Garbage harms more than 250 species of marine animals and birds and releases toxic substances into the water. An interesting fact: garbage thrown into the ocean forms the most real floating continents, the most famous of which is the Pacific garbage spot, which can be seen even from the ISS (International Space Station of NASA). This is a giant collection of garbage in the North Pacific ocean. The area of the spot, according to the most optimistic estimates, is at least 700 thousand square kilometers.

All this is accompanied by a loss of spirituality and faith. If we do not take urgent measures to change the paradigm of the world economy, we will soon have to decide whether to be or not to be. But few people think about it. Most are engaged in extracting funds to the detriment of health, mental and physical, to gain access to unnecessary garbage. And we must not forget and firmly remember that where we all go sooner or later, you can not take anything with you.

How should we act to protect the planet from destruction as a result of an absurd consumer society, from this flood of unnecessary items and services? Solving the problem of saving the planet and, in fact, humanity from destruction is one of the most important tasks of reforming the entire system of life on earth in the 21st century. The last meetings of the world economic forum in Davos were dedicated to this. The world community and individual representatives of big business realized the essence of the impending disaster. We need a new model of development that provides current and future generations with all the necessary resources for life.

Such a model of the world economy in the 21st century should become a circular economy, which, based on energy and resource-saving low-volume technologies and network platform solutions, will allow: significantly reduce transaction costs, create compact green settlements with local and decen-

tralized systems to provide the population with the necessary spiritual, material and energy resources for sustainable living, taking into account all environmental principles of environmental protection. The world is entering a new technological era, when horizontal links between market actors (sources and consumers of resources) directly without a single center will change the entire system of life on the basis of the three e principle: Ecology, Economy, Energy (Huzmiev). At the same time, everyone is equal in the network, regardless of the volume of the resource being processed. Each subject of the network itself decides to act independently or transfer its powers under certain conditions to a third party to carry out operational activities for the exchange of resources.

Almost a new economy is an economy with a network architecture with free exchange of all resources between nodes (cells) of the network, which can have the properties of generating, consuming, storing, and transferring resources. At the same time, monitoring, management and decision – making systems for life support should be based on actively adaptive intelligent digital technologies (smart systems). The purpose of such an economy is not profit that destroys the natural environment, but sustainable development that provides current and future generations of people living on earth with the necessary information, material, energy resources and food to maintain a healthy lifestyle and protect the environment, taking into account the region of residence and moral attitudes of a particular ethnic group. This is a growth economy that ensures sustainable development and preservation of the earth's biosphere, with a reduction in the level of consumption of all resources and their restoration.

Today, there is a rapid exponential change in the economic structure within the framework of the fourth industrial revolution of Economy [4] in our opinion, this is a resource-saving system of economic growth based on intelligent active-adaptive automated digital management of all life-support entities in real time, which are combined with the use of decentralized network structures with vertical and horizontal connections between the elements of the system with closed technologies of production, consumption and disposal of consumer items on the basis of decentralized, decarbonized, digital energy. At the same time, all elements of the economy and their associations in the form of cyber-physical systems are displayed as virtual models on digital platforms using the Internet of things and services.

Note that the Fourth Industrial Revolution) - a predicted event, the mass introduction of cyber-physical systems in production (industry 4.0) [1], serving human needs, including life, work and leisure. Changes will cover a variety of aspects of life: the labor market, the living environment, political systems, technological structure, human identity, and others [2]. The fourth industrial revolution carries risks of increasing instability and possible collapse of the world system [3]. Humanity is on the edge of a new technological revolution that will radically change the way we live, work and relate to each other, Klaus Schwab noted in Davos in 2017, while the world is waiting for challenges and risks that can lead the environment along with humanity to the death and collapse of everything conceived. The digital world of a new technological order is coming, full of dangers and uncertainty.

It is necessary to realize that further economic growth based on unrestrained consumption of energy and resources cannot be sustainable, due to resource constraints due to the finite size of the planet and the growth of the population. This is why the current economy of unrestrained growth is being replaced by a low-cost active-adaptive intelligent (Smart) “green economy” based on digital information technologies, or as it is also called digital economy 4.0, which is the basis of sustainable development. This means: meeting the needs of current and future generations of people with a normalized amount of life-supporting resources for all categories of consumers, sufficient to maintain a healthy lifestyle and efficiency while reducing the risks of environmental degradation, as a basis for maintaining environmental, socio-economic and political stability in the world community on the basis of the digital economy 4.0 [5, 6]. After all, this is a question of survival, which is not yet realized by the majority in our consumer society.

Conclusion

Humanity will be able to survive in the 21st century only if, in the context of the new globalization, the first place will be put not the profits of individual individuals, transnational financial groups and oligarchs, but the needs of any person living on earth to ensure an economically and environmentally sustainable future. These include modern digital information systems, renewable energy sources, local production of goods and services, green farming, socially oriented public relations, democratization

and election of government bodies and the judicial system, and security.

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Hazelnut diseases and their causing pathogens in the hazelnut-growing regions of Georgia

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ABSTRACT

Hazelnut (*Corylus avellana* L.) is an important agricultural crop for Georgia and one of the main agro-export products. Significant reductions in hazelnut production in recent years and a deterioration in its quality have necessitated certain research measures. Based on the three-year study conducted in 24 sample plots of hazelnuts in Samegrelo, Guria and Kakheti Regions, a wide range of hazelnut diseases is revealed. In particular, 18 pathogenic microorganisms were isolated and identified on hazelnut stems and fruits. Fifteen of them are fungal, one - bacterial, and two - viral pathogens. The incidence of each pathogen and the three-year average disease prevalence rates are determined.

Keywords: Hazelnut (*Corylus avellana* L.), Hazelnut diseases, Phytopathogenic microorganisms, Symptoms, Isolation, Identification.

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Introduction

Hazelnut (*Corylus avellana* L.) is an important agricultural crop for Georgia and one of the main agro-export products, which allows the country to be among the top five hazelnut producing countries in the world. However, over the past three to four years, the quality of hazelnuts has decreased, and its export earnings have dropped significantly [1], which was facilitated by widespread of fungal diseases and the appearance of various pests in western Georgia [2,3].

According to experts, in 2017-2018 there was a strong spread of pathogenic fungi of hazelnuts, outbreaks of diseases, or epiphytotics [4]. The rot of the hazelnut fruit increased sharply. There are known various scientific studies of pathogenic microorganisms found in the culture of hazelnuts. [5-8]. It is also noteworthy that there are different types of hazelnut defects, such as: hollow fruit, rotten fruit with black tip, crushed heart with brown spots, var-

ious spots on the fruit, etc. Some of them are considered to be a physiological problem of the plant, while others are associated with fungal diseases and pests [9-14].

The results of systematic-ecological research of fungi spread on hazelnut plants are of great importance for the viability and high productivity of the hazelnut plant [15]. The influence of various factors on the spread of diseases has been studied [16]. According to literary sources, more than 100 pests and more than 20 different diseases have been registered on hazelnut crops by scientific researchers [17,18]. The current problems in the hazelnut growing areas have made it necessary to identify their causes and search for the ways to solve them, it has become important also to identify and clarify the causes of diseases and develop appropriate control measures.

In 2018-2020, we conducted surveys in both eastern and western Georgia in order to identify hazelnut diseases and their causes. In eastern Georgia,

observations were carried out in Kakheti (Kvareli municipality), while in western Georgia, the Samegrelo (Zugdidi, Chkhorotsku, Abasha municipalities) and Guria (Ozurgeti municipality) region were determined for this purposes.

Research objects and methods

The research took place in hazelnut growing plots from late April to October. These hazelnut orchards were studied in 12 villages of Samegrelo,

10 villages of Guria and 2 villages of Kakheti. The GPS coordinates of the recording locations are given in **Table 1**.

The data has been obtained according to the method adopted in the field of plant protection, on equal-by-size areas allocated in several different places on the diagonal of the plot, on all four sides of the selected plants. For the monitoring, we used the visual observation method and a magnifying glass. Diagnostics of the diseases was made both on the basis of visual observations and in the laborato-

Table 1. Location of the research object and its coordinates

Regions	Sampling villages	GPS coordinates	Height above sea level (m)
Samegrelo	Ingiri	42°30'17" N 41°49'08" E	82
	Kakhati	42°29'51" N 41°45'41" E	48
	Mikava community	42°37'18" N 42°06'13" E	266
	Narazeni	42°24'54" N 41°56'52" E	103
	Darcheli	42°26'21" N 41°41'19" E	12
	Natsuluku	42°33'37" N 41°52'46" E	141
	Pakhulani	42°39'12" N 41°57'45" E	190
	Akhalsopeli	41°54'17" N 45°59'11" E	439
	Ganmukhuri	42°25'43" N 41°37'40" E	5
	Chitatskari	42°28'38" N 41°51'58" E	60
	Tqviri	42°10'11" N 42°14'43" E	21
	Shamgona	42°31'09" N 41°46'10" E	60
Guria	Makvaneti	41°54'30" N 42°00'55" E	93
	Chochkhati	42°01'51" N 41°54'39" E	92
	Shua Amaghleba	42°02'30" N 42°12'31" E	18
	Melekeduri	41°57'03" N 42°01'35'32"E	99
	Anaseuli	41°54'05" N 41°59'11"E	123
	Likhauri	41°52'36" N 42°00'20" E	132
	Dvabzu	41°56'06" N 42°03'024"E	131
	Shemokmedi	41°54'38" N 42°04'04" E	163
	Gvara	41°49'58" N 41°50'23" E	31
	Naruja	41°54'26" N 41°57'28" E	137
Kakheti	Kvareli	41°56'45" N 45°48'20" E	401
	Shilda	41°59'35" N 45°43'09" E	482

ry with a moist chamber, culturing infected specimens on artificial media and microscopic analysis.

We considered the spread of diseases in separate areas of the gardens with the formula:

$$P = n \times 100 / N$$

Where: P is the percentage of disease spread, n is the number of diseased plants, N is the total number of registered plants.

The average percentage of diseases spread as a result of the conducted monitoring in different areas was calculated by the formula:

$$P_{av} = \Sigma SP / S$$

Where: P_{av} is the average prevalence of the disease, ΣSP is the sum of the multiplication of the percentage of the disease spread over this area of the individual area indicator, while S is the total area.

It was kept records of the symptoms such as: various necroses or white powdery spots on leaves, twigs and fruits, knotted wounds on the stem, deformity on twigs and rot on fruits. Diseased samples were placed in special packages and taken to the laboratory for analysis, where a detailed analysis of diseased samples of hazelnut stems and fruits was carried out.

Isolation and identification of the pathogens

Tissues of the diseased organs of the nut with these symptoms were cleaned with an alcohol and 1% NaOCl solution for 1-2 minutes, and then placed in petri dishes in a moist chamber or transferred into

the tubes with Malt Extract agar (MEA) and Sabouraud dextrose agar (SDA). Both petri dishes and test tubes were placed in a thermostat at a temperature of 23-25 °C. To identify the fungal pathogens, 7-10 days old cultures of the pathogens were studied under the Phase Contrast Microscope at 400X magnification [19-23].

Research results

Studies carried out in 2018-2020 have shown that the number of nut diseases and symptoms on different organs is quite large. It was revealed following symptoms on hazelnut leaves: light and dark brown spots; thin reddish-brown spots; thin brown spots; whitish-gray powdery spots; black powdery spots; yellow spots and rings between veins (**Table 2, Figure 1**).

As can be seen from the table, gray powdery spots on hazelnut leaves were detected in almost all the gardens we surveyed in all regions; Light brown spots were mostly registered in 6 villages of Samegrelo (Ingiri, Kakhati, Mikava community, Darcheli, Ganmukhuri, and Chitatskari), while in Guria they were registered only in 2 villages (Naruja, Makvaneti); Small red spots were observed in 5 villages of Samegrelo and 1 in Guria; Brown spots were found in 5 villages of Samegrelo, 2 of Guria and 1 of Kakheti; Small brown spots were observed only in Samegrelo (Ingiri, Kakhati, Narazeni); Yellow spots and rings were detected only in two villages - Darcheli (Samegrelo) and Likhauri (Guria).

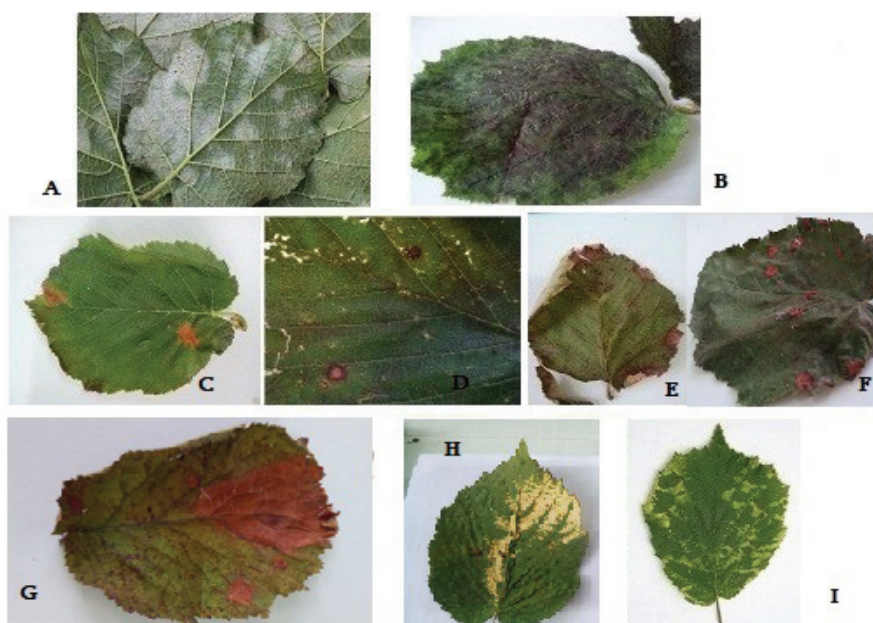


Fig.1. Symptoms detected on hazelnut leaves

A- gray powdery spots; B - black powdery spots; C - G - various spots; H, I - yellow spots and rings

Table 2. *Symptoms of diseases detected on hazelnut leaves by locations*

Sampling villages	Light brown spots	Thin reddish-brown spots	Dark brown spots	Thin brown spots	Whitish-gray powdery spots	Black powdery spots	Yellow spots between the veins
Ingiri	+	+		+	+		
Anaseuli	+	+	+		+		
Kakhati	+		+	+	+	+	
Mikava community	+				+		
Narazeni		+		+	+		
Likhauri					+		+
Darcheli	+		+		+	+	+
Natsuluku					+	+	
Akhalsopeli		+	+		+	+	
Ganmukhuri	+				+	+	
Dvabzu					+		
Chitatskari	+	+			+		
Shemokmedi					+		
Tqviri					+		
Gvara		+			+		
Naruja	+				+		
Kvareli			+		+		
Makvaneti	+		+		+		
Shilda					+		
Chochkhati					+		
Shua Amaghleba			+		+		
Shamgona			+		+		
Melekeduri					+		

The symptoms we observed by monitoring the hazelnut stems are few, to compare with the leaves. Wounds, brown spots and black powdery spots were

Table 3. *Symptoms of diseases detected on hazelnut stems*

Sampling villages	Wounds	Brown spots	Black powdery spots
Akhalsopeli	+	+	+
Ingiri	+	+	
Kakhati	+	+	+
Ganmukhuri	+		+
Natsuluku		+	
Dvabzu	+		
Mikava community		+	
Chochkhati	+		
Darcheli			+

noted on the stems. The data are shown in **Table 3** and **Figure 2**.

As can be seen from the table, the symptoms of the disease on hazelnut stems were observed in a smaller number of orchards compared to the leaves.

**Fig. 2.** *Wound (cancer symptom) on the hazelnut stem*

Table 4. *Symptoms of diseases found in hazelnut kernel and leafy involucre*

Sampling villages	Dark brown rot	Black spots	Thin, brown, sunken spots	Gray powdery spots	Black powdery spots	Green powdery spots	Whitish-pink powdery spots	Undeveloped dried fruits
Ingiri	+	+	+	+			+	
Anaseuli	+	+	+	+			+	
Kakhati	+	+	+	+	+		+	
Mikava community	+	+		+				
Narazeni	+	+	+	+				
Likhauri	+	+		+				
Darcheli	+	+	+	+	+		+	
Natsuluku	+	+			+			
Pakhulani				+	+	+		
Akhalsopeli	+	+	+	+	+		+	
Ganmukhuri	+	+	+	+	+		+	
Dvabzu	+	+		+				
Chitatskari			+	+				
Shemokmedi				+				
Tqviri				+				
Gvara			+	+				
Naruja	+		+	+			+	+
Kvareli		+		+				
Makvaneti	+	+	+	+	+		+	+
Shilda				+				
Chochkhati				+				
Shua Amaghleba		+		+				
Shamgona		+		+				
Melekeduri				+			+	

Disease symptoms revealed on hazelnut kernel and leafy involucre of the nuts are quite numerous (Table 4, Fig. 3,4)

It is clear from the Table 4 that gray powdery spots were observed in most places on the fruit of the nut, as well as on the leaves (in almost all

villages); Various spots were detected in up to 14 villages. Undeveloped fruits were observed by us in 2 gardens; We recorded 7 black powdery spots, 8 white-pink powdery spots, and 1 green powdery spots in 1 village;

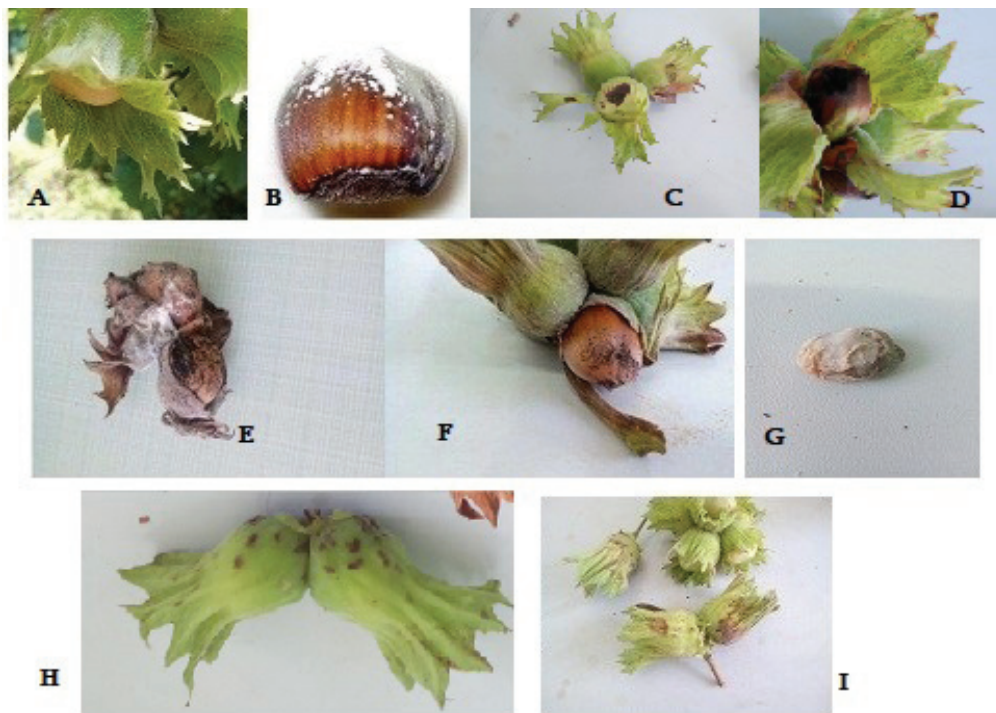


Fig. 3. Symptoms of diseases on the kernel of the nut

A - gray powdery spots on leafy involucre ; B - white powdery spots on a hazelnut seed coat; C - black powdery spots on leafy involucre; D - greyish brown rot on seed coat and leafy involucre; E - F

- powdery spots and black dots on the seed coat; G - whitish-pink powdery spots on the kernel; H - I - thin, brown, sunken spots on the leafy involucre



Fig. 4 Rotten kernel samples

Whitish-gray powdery spots characteristic of the powdery mildew was dominated in percentages among the symptoms on the leaves . The presence of yellowish spots and rings between the veins were rel-

atively rare. The percentages of symptom prevalence and the pathogens corresponding to these symptoms that we have identified are given in **Table 5**.

Table 5. Average Percentage of Diseases Detected on Nut Leaves by Symptoms (2018-2020)

Symptoms Pathogen	Light brown spots	Thin reddish-brown spots	Dark brown or brown spots	Thin brown spots	Gray powdery spots	Black powdery spots	Yellow spots or rings between the veins
	Prevalence %						
	6	4	3	2	15	10	2
<i>Erysiphe corylacearum</i> U. Braun & S. Takam					+		
<i>Phyllactinia guttata</i> Kar.					+		
<i>Gloeosporium coryli</i> (Desm.) Sacc.	+	+					
<i>Colletotrichum acutatum</i> J.H.	+	+					
<i>Alternaria coryli</i> Israf.			+				
<i>Pestalotiopsis</i> sp.			+				
<i>Phyllosticta</i> sp.				+			
<i>Cercospora</i> sp.	+			+			
<i>Phomopsis</i> sp.			+				
<i>Xanthomonas arboricola</i> Vaut. pv. <i>Corylina</i>		+					
Apple chlorotic leaf spot virus (ApMV);							+
Prunus necrotic ringspot virus (PNRSV)							+

The percentages of the prevalence of the symptoms detected on the stem and the corresponding pathogens of these symptoms identified by us are

given in Table 6, while the same rates in the case of the kernels and leafy involucre are shown in Table 7.

Table 6. Percentage of disease prevalence on hazelnut stem by symptoms (2018-2020)

Symptoms Pathogen	Wounds	Brown spots	Black powdery spots
	Prevalence %		
	2	3	5
<i>Nectria ditissima</i> Tul.	+		
<i>Capnodium</i> sp.			+
<i>Pestalotiopsis</i> sp.		+	
<i>Xanthomonas arboricola</i> Vaut. pv. <i>Corylina</i>		+	
<i>Colletotrichum acutatum</i> J.H.		+	
<i>Gloeosporium coryli</i> (Desm.) Sacc.		+	

Table 7. Average Percentage of Diseases Detected in Nut kernels and leafy involucre by Symptoms (2018-2020)

Symptoms Pathogen	Dark brown rot	Black spots	Thin, brown, sunken spots	Gray snowflake	Black powdery spots	Green powdery spots	Whitish-pink powdery spots	Undeveloped dried fruits
	Prevalence %							
	10	5	5	7	2	0.5	3	4
<i>Colletotrichum acutatum</i> J.H.	+		+					+
<i>Pestalotiopsis</i> sp.	+	+						
<i>Trichotecium roseum</i> Fr.							+	
<i>Erysiphe corylacearum</i> U. Braun & S. Takam				+			+	+
<i>Phyllactinia guttata</i> Kar.				+			+	+
<i>Alternaria coryli</i> Israf.		+						
<i>Fusarium</i> sp.							+	
<i>Xanthomonas arboricola</i> Vaut. pv. <i>Corylina</i>			+					
<i>Capnodium</i> sp.					+			
<i>Gloeosporium coryli</i> (Desm.) Sacc.	+		+					+
<i>Phomopsis</i> sp.	+	+						
<i>Aspergillus</i> sp.					+			
<i>Penicillium</i> sp.						+		

Tables 5-7 show that gray powdery spots are common in hazelnuts and reach 15% on leaves and 7% on green fruits. Black powdery spots (10% on leaves, 7% on stems and 2% on fruits) also have high rates of spread among the symptoms. According to the prevalence, different spots may be observed, the percentages of which vary from 2% to 10% by organs. The prevalence of other symptoms of nut diseases do not exceed 0.5% - 4%.

By laboratory analysis of the symptomatic samples taken in the field conditions of the hazelnut growing areas, we have identified under the microscopic examination various diseases and their pathogenic microorganisms on the basis of morphological signs. The results are shown in Table 8 and Figure 5.

Based on our research, it is established that among the detected pathogens in the hazelnut plots

of Samegrelo, Guria and Kakheti regions, the pathogenic microorganism *Erysiphe corylacearum* U. Braun & S. Takam is characterized with the highest prevalence (in all 24 locations), which occurs on the leaves, twigs, and fruits of the plant. The second position by this indicator take *Gloeosporium coryli* (Desm.) Sacc. and *Colletotrichum acutatum* J.H. (9 locations) See. **Fig. 5**.

Thus, based on 3-year study of 24 locations in the hazelnut growing areas in different regions of Georgia, we can conclude that the range of hazelnut diseases is quite diverse. We have isolated and identified 18 pathogenic microorganisms on hazelnut stems and fruits. Of these, 15 are fungal, 1 bacterial and 2 viral pathogens. These pathogens cause great damage to the hazelnut crop and significantly reduce the yield and its quality.

Table 8. Pathogens detected in hazelnut orchards in the regions of Georgia (2018-2020)

Name of the disease	Causing pathogen	Diseased organ	Villages of detection of the disease
Powdery mildew	<i>Erysiphe corylacearum</i> U. Braun & S. Takam	Shoot, leaves, fruit	Ingiri, Anaseuli, Naruja, Kakhati, Chitatskari, Akhalsopeli, Makvaneti, Mikavacommunity, Darcheli, Kvareli, Shilda, Narazeni, Likhauri, Natsuluk, Ganmukhuri, Dvabzu, Shemokmedi, Tqviri, Chochkhati, Shuaamaghleba, Shamgona, Melekeduri, Pakhulani
	<i>Phyllactinia guttata</i> Kar.	Shoot, leaves, fruit	Kvareli, Shilda
Anthracnose disease	<i>Gloeosporium coryli</i> (Desm.) Sacc.	Shoot, leaves, fruit	Chitatskari, Darcheli, Ganmukhuri, Naruja, Mikavacommunity, Kvareli, Shilda, Akhalsopeli, Natsuluk
	<i>Colletotrichum acutatum</i> J.H.	Shoot, leaves, fruit	Anaseuli, Naruja, Kakhati, Makvaneti, Ingiri, Narazeni, Mikavacommunity, Likhauri, Dvabzu
Common stem cancer	<i>Nectria ditissima</i> Tul.	Stem-branches	Ingiri, Akhalsopeli, Chochkhati, Kakhati, Dvabzu
Alternaria disease	<i>Alternaria coryli</i> Israf.	Leaves, fruit	Kvareli, Darcheli, Kakhati, Akhalsopeli, Makvaneti, Shuaamaghleba, Anaseuli
Fumagina (Sooty mould)	<i>Capnodium</i> sp.	Stem-branches leaves, fruit	Kakhati, Ganmukhuri, Akhalsopeli, Darcheli
Grey necrosis	<i>Pestalotiopsis</i> sp.	Shoot, leaves, fruit, bud	Kakhati, Darcheli, Anaseuli, Akhalsopeli, Shuaamaghleba, Shamgona, Makvaneti, Ingiri
Leaf spot	<i>Phyllosticta</i> sp.	Leaves	Ingiri, Narazeni
Cercosporiose	<i>Cercospora</i> sp.	Leaves	Darcheli, Kakhati
Fusarium kernel rot	<i>Fusarium</i> sp.	Fruit, bud	Kakhati, Anaseuli, Makvaneti, Melekeduri, Akhalsopeli, Darcheli
Phomopsis disease	<i>Phomopsis</i> sp.	Shoot, leaves, fruit	Naruja, Darcheli, Akhalsopeli, Anaseuli, Makvaneti
Pink rot	<i>Trichotecium roseum</i> Fr.	Fruit	Ganmukhuri, Akhalsopeli, Naruja, Darcheli, Ingiri
Black mold	<i>Aspergillus</i> sp.	Fruit	Makvaneti, Natsuluk, Pakhulani, Akhalsopeli
Green mold	<i>Penicillium</i> sp.	Fruit	Pakhulani
Bacterial blight	<i>Xanthomonas arboricola</i> Vaut. pv. <i>Corylina</i>	Shoot, leaves, fruit	Anaseuli, Gvara, Chitatskari, Akhalsopeli
Hazelnut ring spot	Apple chlorotic leaf spot virus (ApMV); Prunus necrotic ringspot virus (PNRSV)	Leaves	Darcheli, Likhauri
Hazelnut mosaic	Prunus necrotic ringspot virus (PNRSV)	Leaves	Darcheli

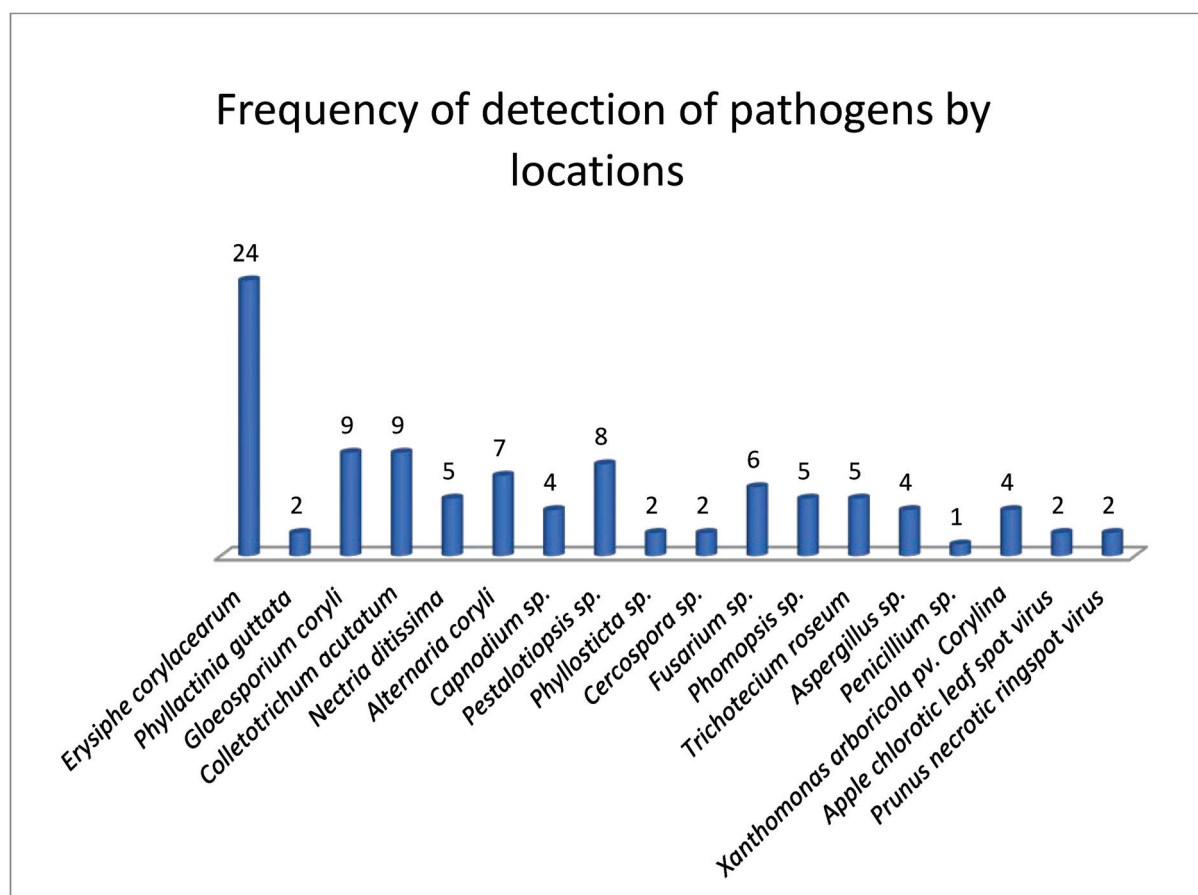


Fig. 5. Frequency of detection of pathogens on hazelnut leaves, stems and fruits, 2018-2020

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Catechins and antioxidant activity of tea products

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ABSTRACT

The paper presents the results of studies of catechins and antioxidant activities of extracts of various experimental and commercial types of tea by using High-performance liquid chromatography method (HPLC). The best solvent eluents of the stationary phase of this method and the two different detection waves have been established. The study presents catechins and antioxidant activities of 12 different kinds and origins of experimental and commercial tea extracts. The quantitative composition of the four catechins in commercial tea samples has been studied in detail. Due to the chemical composition of raw materials and processing technology, high values of antioxidant activity and amount of catechins - epigallocatechingallate and epigallocatechine in experimental and commercial samples of Georgian green, red and black tea have been determined.

Keywords: Tea, Catechins, Antioxidant activity, HPLC, Individual catechins, Tea leaf.

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Background

Tea is produced from the plant *Camelia sinensis* (L) O. Kuntze, as result of the technological processing, the most important taste properties and biological activity of which are determined by polyphenols, primarily catechins. Fundamental studies have confirmed the high P-vitamins activity, antioxidant, anti-inflammatory, antimicrobial, antiviral, anticancer and anticoagulant activities of these substances. The ability of catechins shows to alleviate cardiovascular, atherosclerotic, and hypertensive diseases, to reduce harmful level of cholesterol in the body. To a large extent, the positive action and quantity of epigallocatechingallate determines the health benefits of green tea. Tea consumption is correlates with low incidence of cardiovascular disease and cancer [1 - 9]. Green tea epigallocatechin gallate is characterized by a pronounced ability to stop obesity and metabolic syndrome [10 - 15]. High therapeutic

and prophylactic properties are also maintained by catechin conversion products - theaflavins [16]. Tea consumption can play an important role in providing the human body with antioxidants [17].

The antioxidant activity of tea is due to phenolic compounds and individual catechins, the amount and ratio of which depends on the plant variety, environmental conditions, the period of raw material production, the technological process and some other factors [18]. Tea quality control, in accordance with the requirements of international and national standards, provides for the determination of both the total number of polyphenols as well as catechins [19, 20].

Comparative data on the individual catechins and antioxidant activities of Georgian tea products by various technologies, including imported tea products, are quite scarce [21].

The aim of this paper is to study the individual

catechins and antioxidant activities of ready-made tea extracts of different types and origins.

Research objects and method

The following experimental and commercial tea products are used as research objects:

1. Tea leaf polyphenols concentrate;
2. Fixed tea leaf;
3. Experimental Georgian green tea;
4. “Greenfield” (Georgian green tea);
5. “Shemokmedi” (Georgian green tea);
6. “Royal Richards” (Chinese green tea);
6. “Gurieli” (Georgian green tea);
7. Experimental Georgian red tea;
8. Indian black tea (BOPF);
9. Experimental Georgian black tea;
10. Georgian black tea “Kolkhida”;
11. Black tea granulated (CTC).

Extracts are obtained in the same way as tea tasting and consumer tincture preparation, with single extraction of samples. Consequently, the obtained data do not claim a complete quantitative analysis of the compounds present in the plant material. To prepare the extracts for the analysis of antioxidant activities, 35 ml of boiling water is added to a 0.5 g tea sample. The extraction process takes 20 minutes. The 60 μ l sample is taken from the extracts obtained and antioxidant activities are determined. To obtain catechin analysis extracts, 0.5 ml of boiling water is added to a 0.5 g sample of tea, the duration of the process being 20 min. The 10 μ l samples taken from the extracts are analyzed by high

performance liquid chromatography. High performance liquid chromatograph Agilent 1260 Infinity (USA) and chromatographic column Supelco - C18 (25 cm $\times$ 4.6 mm, 5 μ m), temperature 250 C. Rolling phase - acetonitrile, 1% acetic acid dissolved in desalinized water to purify. Accepted using system Millipore (Merck, Germany) were used. Detection is performed using a single-signal ultraviolet detector at different wavelengths - 210 and 278 nm. The calibration curve is constructed at different concentrations of epigallocatechin gallate. The total amount of phenolic compounds and antioxidant activity in experimental and commercial tea products were determined using the relevant methods in the literature [19, 22, 23].

Statistical analysis

The results are expressed as mean $\pm$ SEM. Student's t-test was used to analyze level of statistical significance between groups. $P < 0.05$ was considered statistically significant.

Results and Discussion

The study results show a direct dependence between the antioxidant activity of tea extracts and the total amount of polyphenols (Fig. 1). Indicators distinguished the liquid concentrate of fixed tea leaf polyphenols made by special technological process [22]. According to a study of the total amount of antioxidant activities and polyphenols, tea samples

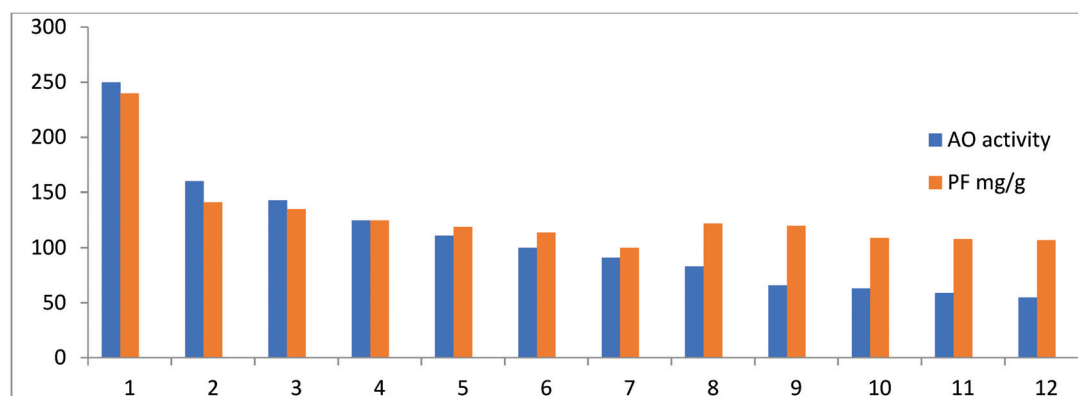


Fig. 1. Total amount of polyphenols (PF), mg/g and antioxidant activity (AO) $R=1/S \text{ sec.} \times 1000$ in tea

1-Tea leaf polyphenols concentrate; 2 - Fixed tea leaf; 3 - Experimental Georgian green tea; 4 - “Greenfield” (Georgian green tea); 5 - “Shemokmedi” (Georgian green tea); 6 - “Royal Richards” (Chinese green tea); 7 - “Gurieli” (Georgian green tea); 8 - Experimental Georgian red tea; 9 - Indian black tea (BOPF); 10 - Experimental Georgian black tea; 11 - Georgian black tea “Kolkhida”, 12 - Black tea granulated (CTC)

data were different. The total amount of polyphenols in black tea extracts was quite high as green tea, although they are characterized by fewer antioxidant activity properties. This is due to the fact that catechins of high antioxidant activity are oxidized in black tea extracts.

The total amount of polyphenols in black tea

sample extracts is also quite high, although this type of product is characterized by less antioxidant activity. This may be due to the lack of epigallocatechin gallate, which causes antioxidant activity in the extracts of these products, or the lack of secondary compounds that are also characterized by high antioxidant activity in vitro experiments.

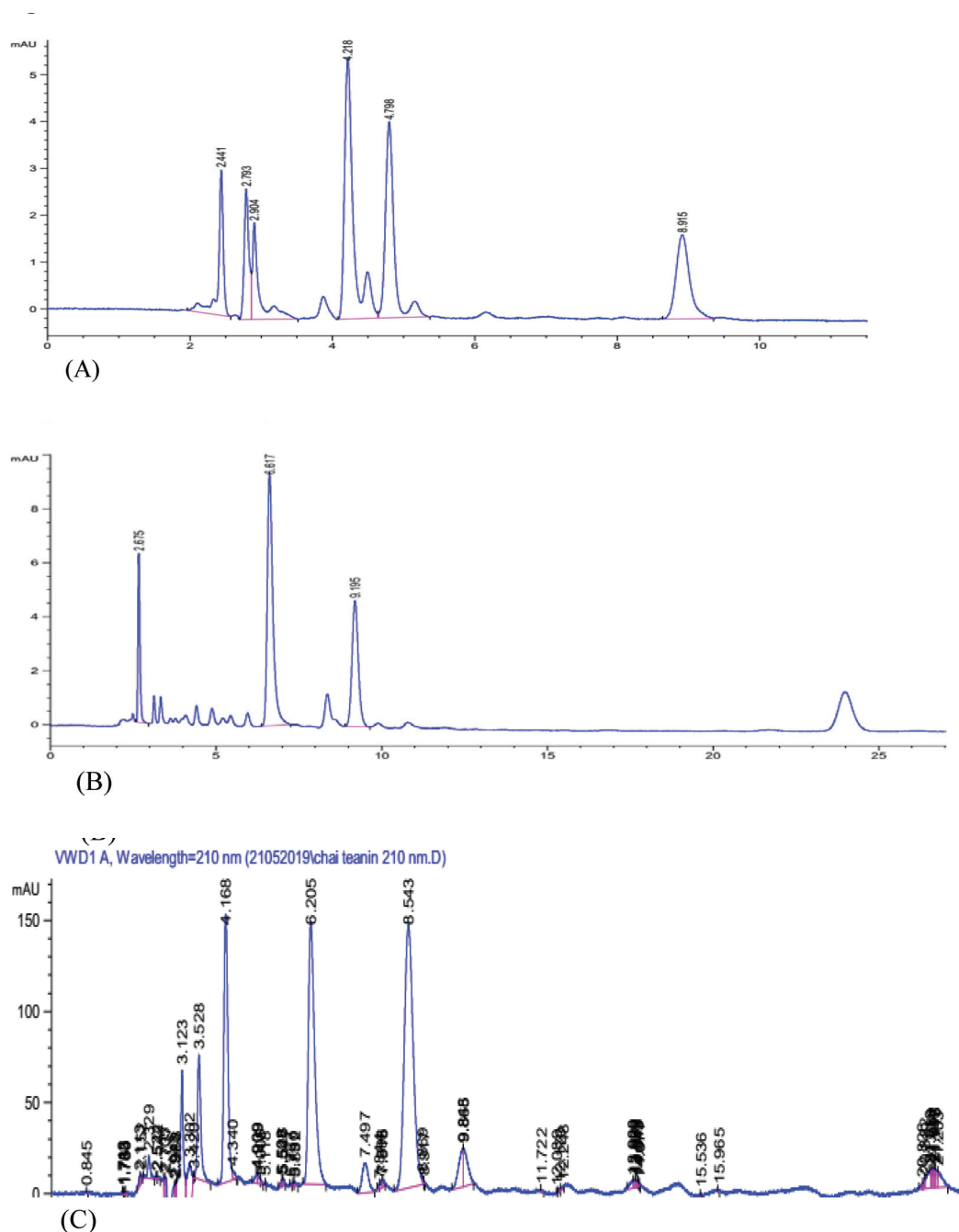


Fig. 2. Chromatographic profiles of green tea extracts according to different elements and detection wave:

A- Acetonitrile – water 1% acetic acid 15 : 85, detection at 278 nm;

B –Acetonitrile – water 1% acetic acid 20 : 80, detection at 278 nm;

C –Acetonitrile – water 1% acetic acid 15 : 85, detection at 210 nm

Fig. 2 presents the results of a study of the chromatographic separation of catechins under two different variants of the eluent ratio. At relatively high concentrations of acetonitrile (20:80) the division proceeds more rapidly, and the peak of the last catechin epicatechin gallate leaves the column earlier according to the retention of time. Although the eluent is acetonitrile - water, the chromatography time is longer at 15: 85, but the separation peaks are more pronounced. Especially in the beginning,

when the division is underway into major catechins. Important fact is that the peak of the epigallocatechin gallate is pronounced and can be counted most accurately. From the obtained data it can be seen that 210 Under the conditions of Nm wave detection, the intensity of the corresponding peaks of the catechins increases, while that of caffeine and other compounds decreases (Fig. 2 (C)). This is important for determining the degree of catechin separation and their identification.

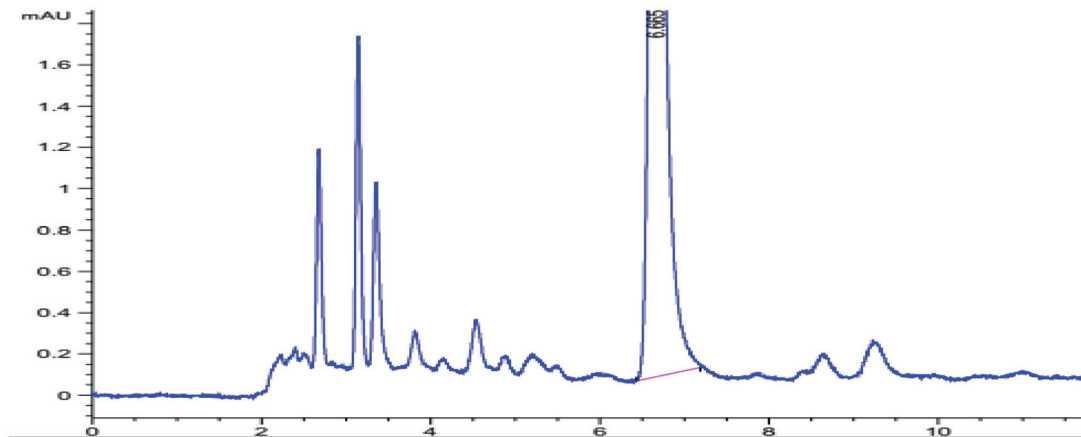
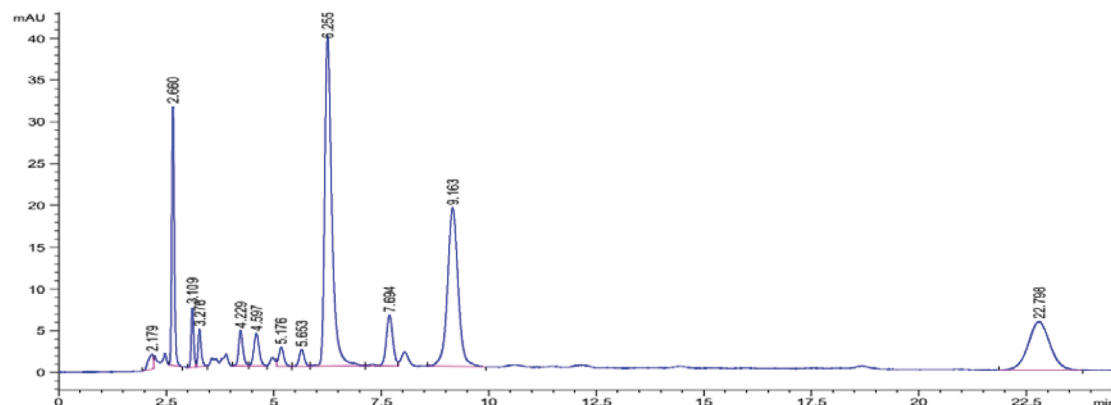


Fig.3. *Chromatographic profile of black tea*

Fig. 3 shows the chromatographic profiles of black tea catechins. Acetonitrile water 1% acetic acid 15:80 was used as the eluent. Chromatograms show that the concentrations of epigallocatechin gallate as well as galocatechin, epigallocatechin

and epicatechin are low in black tea extract. At the same time increased peaks, which according to time constraints and literary data [22] can be considered as representatives of the Teaflavins and Thearubigins (Fig. 3, peaks from left 2 and 3).



(A)

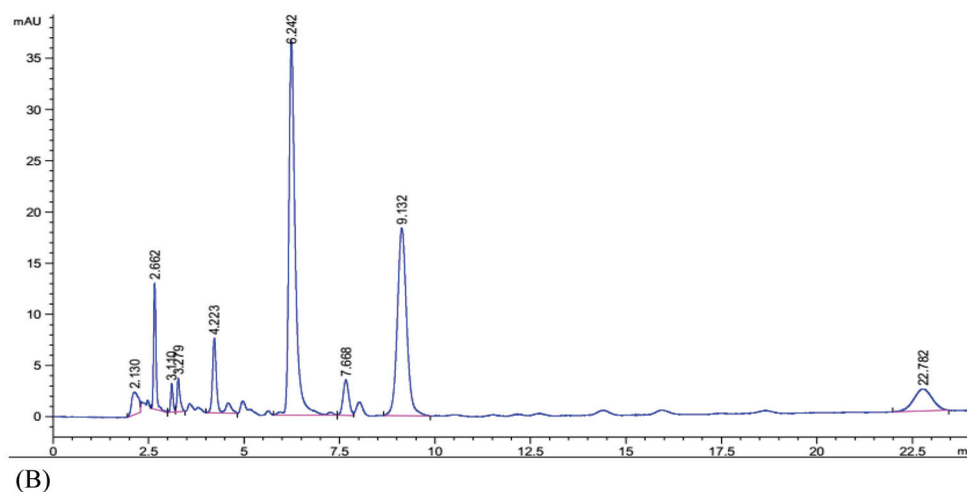


Fig. 4. Commercial green tea chromatograms: A - "Greenfield"; B - "Shemokmedi"

The chromatograms shown in Figure 4 reveal the four major peaks of catechin by time retention (min): 4.2 - epigallocatechin; 7,6 - epicatechin; 9.1 – epigallocatechin gallate and 22.7 – epicatechingallate.

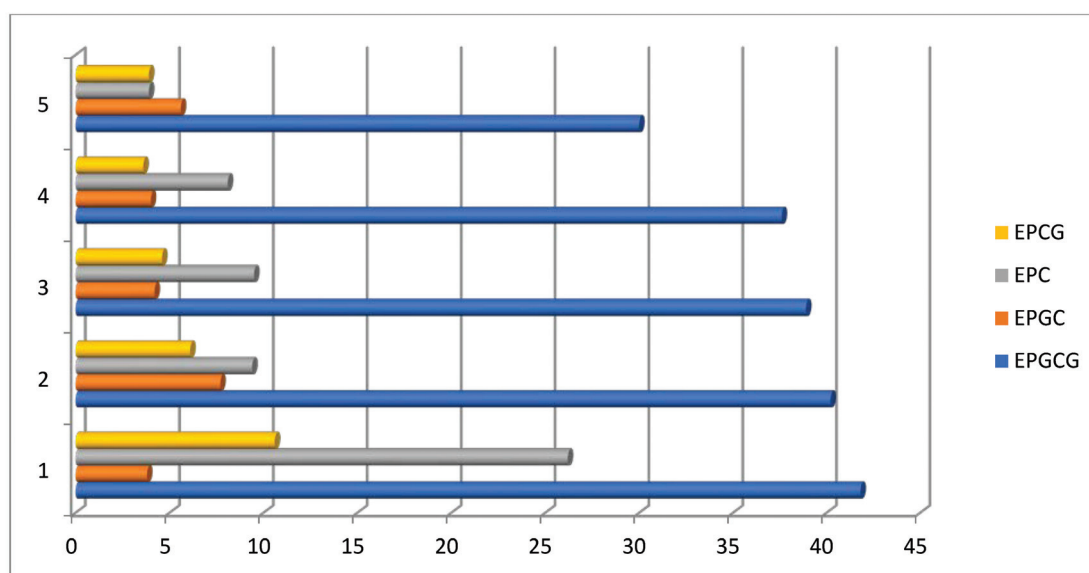


Fig.5. Comparative amount of four catechins in commercial green tea extracts: "Greenfield"; 2- "Shemokmedi"; 3 - "Richards"; 4 - "Akhmad"; 5 - "Gurieli"

Based on the results of quantification of catechins, the high content of epigallocatechin gallate in commercial green tea extracts "Greenfield" and "Shemokmedi" has also been verified (Fig. 5). On the other hand, compared to imported green tea, Georgian commercial tea "Shemokmedi" and "Gurieli" contain more epigallocatechin. It is noteworthy that the epigallocatechin, like the epigallocatechin-gallate, is also characterized by high biological activity, as evidenced by the literature [14, 15].

The study results of experimental tea extracts show high rates of red tea in terms of total phenols, antioxidant activity and individual catechins (Fig. 6), which is due to the use of a new technological process for making this type of tea.

It is planned to continue the work of creating and researching new types of tea products with high catechin substitution, high antioxidant activity, low caffeine and distinctive taste properties in the future.

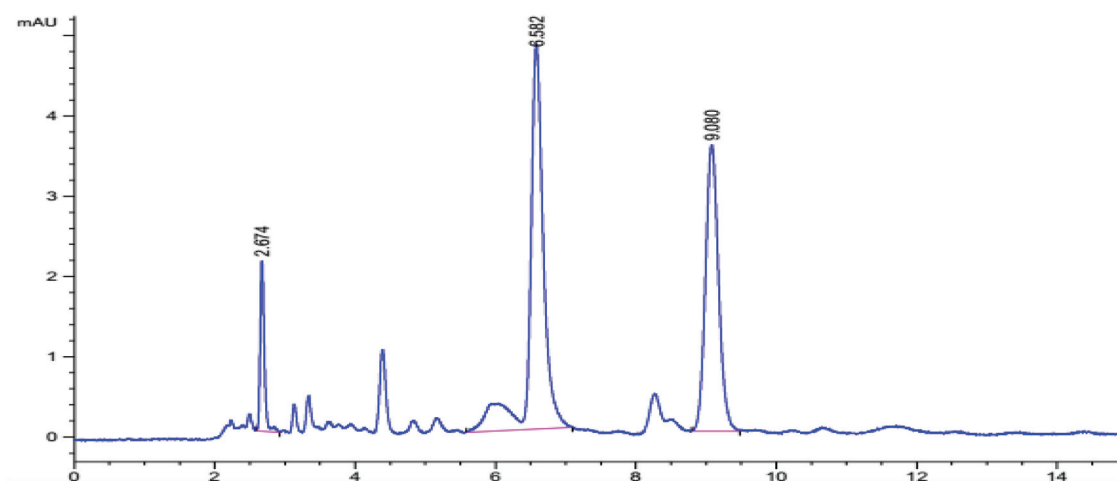


Fig. 6. *Chromatographic profiles of experimental red tea samples*

Conclusion

1. The best eluent solvents under the stationary phase conditions of the high performance chromatographic method are selected. Detection of compounds at 278 and 210 nm under two different wave conditions allows to increase catechin peaks and more accurately identify these substances.

2. Catechins and antioxidant activities of 12 different types and origins of experimental and commercial tea extracts have been studied by using a high pressure chromatographic method. Particular catechins are examined in detail: epigallocatechin-gallate, epigallocatechin, epicatechin and epicatechingallate.

3. High rates of experimental and commercial tea products of Georgian population with antioxidant activity and catechins are established - According to the amount of epigallocatechin gallate and epigallocatechin. the high substitution of epigallocatechingallate in the commercial Georgian green tea extract “Shemokmedi” is worth emphasizing.

4. Along with the distinctive taste properties, high rates of experimental red tea have been shown in terms of total phenolic compounds, antioxidant activity and individual catechins, resulting from instantaneous and deep inactivation of oxidizing enzymes in the technological process of making this product.

The manuscript is dedicated memory of the late Professor Mikhail Zaprometov, who was a prominent scientist in the field of biochemistry of phenolic compounds. It was during the study of the biochemical study of Georgian tea, that Mikhail Zaprometov obtained the first crystalline compounds of Georgian

tea catechins in 1952, which gave scientists even more incentive and opportunity for research. The idea of working on tea catechins arose during the celebration of the 100 th anniversary of the birth of Mikhail Zaprometov, the memory of which is dedicated to the present article.

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Diversity of wheat in modern Georgia versus discoveries of the archaeological excavations of the 6,000 BC Neolithic sites of Lower Kartli Region (SE Georgia)

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A B S T R A C T

Georgia is one of the most important centers for the diversity of domesticated wheat. It is the only country in the world where all wheat genomes (AA, AABB, AAGG, AAGGAA, AABBDD) and all seven, domesticated hulled wheat species are present. The diversity of the wheat species (15) in Georgia is higher than in any other country including the Fertile Crescent region. Such diversity could originate only in the areas of ancient agricultural traditions. Archaeological excavations of the Neolithic sites of Arukhlo, Khramis Didi Gora and Gadachrili Gora in Kvemo [lower] Kartli Region (south-east Georgia) confirmed that wheat has been cultivated in Georgia since at least 7th and in the beginning of the 6th millennia BC, when the Shulaveri – Shomu Culture appeared in East Georgia. As many as nine wheat species were identified in Arukhlo suggesting that hulled and free-threshing wheats of all ploidy levels were already produced there. Among them, there are 4 species of hexaploid wheats: *T. spelta*, *T. sphaerococcum*, *T. aestivum*, *T. compactum*. Interestingly the appearance of naked tetraploid wheat species of *T. carthlicum* and *T. durum* in the oldest layers of Arukhlo. The palaeoethnobotanical material of later Neolithic site Chikhori (Imereti, West Georgia) is identical to the botanical materials of Arkhulo and Khramis Didi Gora.

Keywords: Triticum, Endemic, Hexaploid wheat, Neolithic, Hulled wheat, Georgia.

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Introduction

Georgia is one of the most important centers for the diversity of domesticated wheat. It is the only country in the world where all wheat genomes (AA, AABB, AAGG, AAGGAA, AABBDD) and as many as 15 species (s. str.) of wheat (*Triticum boeoticum* Boiss., *T. monococcum* L., *T. dicoccum* (Schrank) Schübl., *T. palaeocolchicum* Menabde, *T. timopheevii* (Zhuk.) Zhuk., *T. durum* Desf., *T. tur-*

gidum L., *T. carthlicum* Nevski, *T. macha* Dekapr. & Menabde, *T. zhukovskyi* Menabde & Ericzjan, *T. turanicum* Jacobz., *T. polonicum* L., *T. spelta* L., *T. compactum* Host, *T. aestivum* L.) are found. Among them 5 species (*T. macha*, *T. palaeocolchicum*, *T. timopheevii*, *T. zhukovskyi* and *T. carthlicum*) are endemics [1-7]. The same diversity is reflected in the material obtained from the archaeological excavations of the 6th millennium BC Neolithic sites of Arukhlo and Khramis Didi Gora in Kvemo [lower]

Kartli Region (southeast Georgia) providing evidence that Georgia is an important center of wheat domestication.

Main part

Ancient domesticated hulled wheat species survived until the 1970-ies in the western provinces of Georgia, such as Lechkhumi, Racha and Svaneti. As a rule, more advanced species replace their predecessors due to higher productivity or better adaptation to local environment or crop management practices. That is why hexaploid free-threshing wheat replaced hulled wheats almost in all ancient wheat growing regions including the Fertile Crescent countries, where some of the ancient wheats were domesticated. In contrast to the other countries, West Georgia is a rare example of a country, where wheat species of different epochs are produced in the same area and as part of the same production system. It is worth of mentioning that ancient hulled wheat and free-threshing wheat species have been produced together in Lechkhumi, Racha, and Svaneti for at least 8000 years. However, this diversity of Georgian wheat is under the threat of extinction, particularly since the 1980s and 1990s and nowadays Georgian endemic species are not cultivated anymore in the places of their origin, in the provinces of Lechkhumi, and Racha (West Georgia).



Fig. 1. *Snakvi* - the oldest tool for harvesting hulled wheat species of *makha* and *zanduri*

Georgia is the only country in the world where all 7 species of hulled wheat are present (among them 4 endemic species). Georgian endemic hulled wheat species play important role in the evolution of wheat. They represent ancient, relict species, showing all directions and transitional stages in wheat evolution from diploid to tetraploid and hexaploid species [8]. The relict tools used to collect hulled wheat spikes (with brittle rachis) have survived up to present day in Georgia. This is a woody tool, known as ‘Shnakvi’ (Fig. 1), originally created for wheat, and a stone mortar (Fig. 2) for dehusking (peeling) ears of hulled wheat - *makha* and *zanduri*.

According to Nesbitt and Samuel [9] Agriculture in Transcaucasia has always been characterized by great diversity in the range of crops. This must be due in part to isolation of regions within the highly mountainous landscape. The same diversity is found in ancient plant remains [9: 80].

Wheat diversity in archaeological excavations of the Neolithic sites in Georgia



Fig. 2. *Stone mortar “chamuri” for dehusking ears of hulled wheat*

The earliest aceramic (lacking pottery) Neolithic sites in Georgia have been mainly found on the Black Sea coast and in the Colchic (Kolkheti) lowlands (west Georgia). The Neolithic revolution probably began in Georgia in the 8th millennium BC [10,000 BP]. According to the archeological

findings, the Neolithic revolution in Georgia is characterized by a number of innovations: tool production by means of scrubbing and polishing hard rocks, or by means of a macrolithic technique (bilateral slicing), the new shapes of tools, and the advent of pottery production [10].



Fig. 3. Female figurines from the Neolithic sites of the Lower Kartli Region

At the end of the 7th and in the beginning of the 6th millennia BC a Neolithic culture known as the Shulaveri – Shomu Culture appeared in East Georgia [11]. It was diffused over what is now south-eastern Georgia, mainly in Kvemo [Lower] Kartli Region and characterized by settlements in villages, circular vaulted mud-brick homes and farm buildings, tools (made of obsidian, stone, bone and horn). Also female figurines (Fig.3) reflecting fertility beliefs, clay vessels decorated with relief and notched ornaments (Fig. 4) and the farming of domestic animals (cattle, pigs) and cultivation of cereals (wheat, barley) [5, 12]. Wheat, barley, oil-fiber crops, legumes were widely cultivated along with the vineyards and fruit gardens [3, 4, 13, 14].

Nine species of wheat were found in the 6th millennium BC Neolithic settlements of Arukhlo in Lower Kartli Region (south-east Georgia): *Triticum boeoticum*, *T. monococcum*, *T. dicoccum*, *T. carthlicum*, *T. durum*, *T. spelta*, *T. compactum*, *T. sphaerococcum* Percival, *T. aestivum*, eight of which are domesticated species [15]. According to Rusishvili [15], this appearance of naked tetraploid

(AABB) wheat species of *T. carthlicum* and *T. durum* in the oldest layers of Arukhlo is the earliest. As many as seven species of domesticated wheat dating back to 8,000 BP were identified in the archaeological excavations of Lower Kartli (south-eastern Georgia) in Khramis Didi Gora: *Triticum monococcum*, *T. dicoccum*, *T. durum*, *T. spelta*, *T. sphaerococcum*, *T. compactum*, *T. aestivum* alongside with other ‘founder’ crops: barley (*Hordeum vulgare* and *H. distichum*), oat (*Avena sativa*), rye (*Secale cereale*), lentils (*Lens esculenta*), peas (*Pisum sativum*) and bitter vetch (*Vicia ervilia*) [15-18]. By and large, macrofossil remains of crops cultivated by the Neolithic people of the South Caucasus were the same as those ‘founder’ crops of the Fertile Crescent and the Levant [19-21].

Palaeobotanical material and analyzes of archaeological excavations of the Neolithic sites in Georgia shows, that free-threshing, hexaploid wheat species are dominant. Quantity preference of free-threshing wheat species *T. aestivum/compactum*, is evident, percentage of these soft wheat grain is 50-75% of all wheat population [15, 22]. Emmer wheat (*T. di-*



Fig. 4. 8000 years old clay vessels (Kvevri), decorated with relief and notched ornaments from the Neolithic sites of Arukhlo and Khramis Didi Gora in the Lower Kartli Region, SE Georgia (from the Georgian National Museum)

coccum) is the second most abundant wheat species at Neolithic sites (Arukhlo, Khramis Didi Gora), a staple crop second only to soft wheat (*T. aestivum/compactum*). Percentage of emmer wheat is 25-31%. Emmer wheat were less common in Bronze

(ca. 3000 BC) and Iron Age [15, 22, 23, 24].

According Bastert-Lamprichs et al. [26] agriculture in Arukhlo was already well developed in the 6th millennium BC (Fig. 5). A variety of cereals were cultivated: almost the entire range of early



Fig. 5. View of the archeological site of Arukhlo, the Neolithic site of Lower Kartli Region (from [24] photo by S. Hansen)

domesticated crops is available in Arukhlo. Archaeological findings include grains and ears of wheat, which are not cultivated today. For example, the ancient hulled wheat einkorn (*Triticum monococcum*) and emmer wheat (*Triticum dicoccum*), as well as naked wheat (*Triticum aestivum* / *compactum*) can be found in Arukhlo [26]. The excavation in the

burnt area in Arukhlo also brought to light a rich assortment of charred botanical remains (Fig. 6), among others two complete emmer spikes [25].

According to Esakia and Rusishvili [27], the paleoethnobotanical material of the late Neolithic Chikhori (Imereti, West Georgia) is identical to the botanical materials of Arkhulo and Khramis Didi



Fig 6. Emmer spike in the burnt area in Arukhlo (from [24]; photo by S. Hansen)

Gora. On all these monuments (Arkhulo, Khramis Didi Gora, Chikhori) the dominance of the naked free-trashing *T. aestivo-compactum* type was recorded, which implies a high level of wheat evolution. According to the data obtained, in the agriculture of the settlement soft wheat of the *T. aestivo-compactum* type and naked barley *Hordeum nudum* already existed. The existence of mixed sowing of wheat and barley are also assumed [27]. Besides Arukhlo and Khramis Didi Gora, the carbonized grains of *T. dicoccum*, *T. spelta* and *T. aestivum* were also found at Gadachrili Gora, a Neolithic Age (5783 cal. BC or 7775 cal. BP) settlement hill in southeastern Georgia [12]. Wheat grains from Arukhlo, Khramis Didi Gora and Gadachrili Gora provided the earliest archaeological evidence of existence of hulled hexaploid *T. spelta* in the Near East in ca. 6,000 – 5,800 BC. According to Maghradze et al. [28] carbonized seeds of founder crops such as wheat, barley, bitter vetch, lentil, pea together with seeds of some weeds were discovered at “Gadachrili Gora”, confirm the presence of agriculture in Lower Kartli (southeastern Georgia) 8,000 years ago [28, 24].

Wheat grains found in Chikhori are small (L = 4.33 mm), which is typical of club wheat (*T. compactum*). The index of length to width is 1.8. Such

high ratio is typical for bread wheat (*T. aestivum*). Since a sharp boundary between these two species is impossible to identify, wheat grains of such type are considered as a *T. aestivo-compactum* [27].

Not more than 1 or 2 species of domesticated wheat (*T. monococcum*, and/or *T. dicoccum*) were found in almost all of the Anatolian and Mesopotamian Neolithic sites, which are contemporary with Arukhlo [5, 10]. Comparisons between the Shulaveri-Shomu complex and the contemporary Halaf and Hassuna cultures in northern Mesopotamia, and Hacilar in Anatolia show that the cereals cultivated in Transcaucasia are much more diverse than in Anatolia and Mesopotamia [11]. Hamon [11] proposed that the great variety of endemic wheat species in the South Caucasus could have favored local domestication of cereals, even if these cereals were already cultivated in the Near East.

Georgian endemic wheat species as a healthy food

Georgian endemic wheat species Colchic emmer -*T. palaecolchicum* [29] is very similar to wild forms of wheat due to its morphological characteristics. The important agricultural characteristics include: resistance to fungal diseases abundance of fertile spikelets (34-39 spikelets per spike), broad leaves, tall strong stems (100-120 cm tall) used as feed are

important for wheat breeding. Grains of 'Kolchik asli' are distinguished by high protein content, and high lysine content in protein. *T. macha* (makha) bread was highly priced among the local population. It was white, tasty and fragrant and able to stay soft for several days. It was considered an honor to treat guests with 'makha' bread at feasts. 'Zanduri' land-race is considered as the most special local population. Three species are identified in the 'zanduri' population: 1. *T. monococcum* ('gvatsa [narrow] zanduri'); 2. *T. timopheevii* ('chelta [wider] zanduri') and 3. *T. zhukovskyi* ('zanduri'). 'Chelta zanduri' owing to its special immunity to fungal diseases, deserves particular attention. Bread baked from 'chelta zanduri' (*T. timopheevii*) flour is very tasty and flavorful, it remains soft for the whole week. 'Zanduri' (*T. zhukovskyi*) is known as drought and frost resistant plant. It is known by growth potential in all kinds of soils (even in limestone). Free-threshing endemic wheat species 'Dika' (*T. carthlicum*) is characterized by early yielding, easy threshing, resistance to flattening and grain dropping. Grains of 'dika' are also distinguished by their high protein and lysine content. 'Dika' as a highland crop (grows up to 2200 - 2300 m above sea level), is well adapted to severe conditions of the Greater and the Lesser Caucasus Mountains. Its important feature is good bread bake ability. This species is characterized by strong immunity to diseases, frost resistance and a short vegetation period [30].

Endemic Georgian wheat species are important breeding material as they are characterized with high resistance to biotic and abiotic stresses and high grain protein content. The local endemic species are unique as they combine wild and domesticated traits. 15 species of wheat, 188 varieties were registered till 60-70-ies of the last century [7]. At present the situation has radically changed, as the local varieties occupy insignificant areas and their on-farm conservation is under threat. It is necessary preserve the diversity of wheat both at genbank and farms and to restore its production in the places of its origin (especially in Lechkhumi and Racha).

Conclusion

The archeological excavations confirm that wheat has been cultivated on the territory of Georgia since the Neolithic period (from the late 7th and in the beginning of the 6th millennia BC). By that time wheat in Georgia was presented with high diversity including domesticated species providing evidence that wheat cultivation had begun in the 7th

millennium BC. These species represent ancient, relict species, showing all directions and transitional stages in wheat evolution from diploid to tetraploid and hexaploid species and suggesting that the South Caucasus might have played an important role in wheat evolution.

Acknowledgements

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Reduction and uptake of Cr(VI) by *Arthrobacter oxydans* and uptake of Cr(III) by *Arthrobacter* sp. 61B under the influence of potassium and magnesium

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A B S T R A C T

Some bacteria from *Arthrobacter* genera have great potential for bioremediation. Two strains of *Arthrobacter*, one isolated from Georgia, contaminated Kazreti region and second- from Columbia basalt rocks of the contaminated site of the US, exhibit resistance against high concentrations of Cr(VI) and other metallic ions. They can reduce highly toxic and carcinogenic Cr(VI) into Cr(III).

We investigated the behavior of bacteria with following metals: K⁺, Cr(VI) and Mg(II), their uptake process by living, aerobic *Arthrobacter oxydans* and influence of K⁺ and Mg(II) on the uptake process of Cr(III) by *Arthrobacter* sp. 61B. Metal accumulation ability by bacteria, was analyzed using Atomic Absorption Spectroscopy.

Keywords: Cr(VI) reduction, Atomic absorption spectroscopy, Alkali ions, *Arthrobacter* sp. 61B, *Arthrobacter oxydans*, Metal accumulation.

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Introduction

Studying metal-microorganism interactions is one of the most actual issues for environment protection biotechnologists. Microbes' behavior against some metals is of great importance for developing the proper strategy of restoring the contaminated environment, or can be used to develop the method which allows to clean the environment. Some bacteria of *Arthrobacter* genera have great potential for bioremediation, as they exhibit resistance against heavy metals, can transform aromatic compounds and can reduce toxic Cr(VI) into less toxic Cr(III) form [1, 2]. According to its toxicity, Cr(VI) takes the 3rd place between the six most acute environmental pollutants, after lead and mercury [3]. Its toxic action is due to Cr(VI)'s capability to easily penetrate cell membranes both in eukaryotic or prokaryotic cells [4]. Different

non-specific reductants, such as glutathione reductase, cysteine, NADH or other components of the cell: carbohydrates, teichoic, lipoteichoic acids can reduce Cr(VI) by its subsequent Cr(V/IV/III) products [2, 4]. Magnesium Mg(II) takes 11th place between in body existing elements. Mg(II) is essential for all types of living cells and are co-factor of about 300 important enzymes. Mg(II) ions participate in DNA, RNA or Glutathione synthesis. Mg(II) is essential for energy producing processes: oxidative phosphorylation and glycolysis [5]. The potassium (K) ions are among the most important metal ions in living cells. Natural habitats are often characterized by the coexistence of Cr, Mg and K. Coexistence of some metals can cause or synergic or negative effect upon the accumulation/uptake capabilities by different bacteria. Living prokaryotic/eukaryotic cells have separate

transport mechanisms and uptake capabilities for different ions. Against some toxic agents, several resistance mechanisms are known: (1) Changes on bacterial membrane or shell, as a result the barrier for metal ions penetration in cell is increased. Metals' ions (2) Sequestration inside and outside of cell; (3) Driving out from cell using transportation mechanisms; (4) Enzymatic detoxification and (5) weakening the sensitivity of cellular targets [5]. Sequestration or transport mechanisms of different ions, through biological cell membrane are mostly associated with integral membrane proteins: ionic channels. Ionic channel selectivity and transport mechanisms directly depend on ion's hydration energy, atomic radius or valency [6]. Soil microorganisms are influenced by many different metals concomitant action. K^+ , $Cr(VI)$ or Mg^{2+} differ according their valency and atomic radius. They characterize with high solubility in biological fluids. Their salts frequently high solubility in water is due to large entropies of solution while heats of solution often are endothermic [7].

The present data revealed the uptake and reduction potential of $Cr(VI)$ by *Arthrobacter oxydans*, with concomitant action of K and $Mg(II)$. And the uptake capability of $Cr(VI)$ at presence of $400 \mu g/l$ $Mg(II)$ or K ions by bacteria of *Arthrobacter* sp. 61B.

Objects and Methods

Bacterial Growth Conditions, experimental design and sample preparation.

All chemicals were ACS- reagent grade and purchased from Sigma.

Experiment A. Bacterial cells of *Arthrobacter oxydans* were grown aerobically in 250-mL Erlenmeyer flasks as a 100-ml suspension in the medium at $21^\circ C$. The cells were grown with a constant shaking (at a speed of 100rpm). The nutrition medium contained $Cr(VI)$ in the form of K_2CrO_7 (70 mg/L), $MgSO_4 \cdot 7H_2O$ (0.2g/L), K_2HPO_4 (2g/L), ammonium citrate (1g/L), glucose (1g/L), yeast extract (1g/L), and 1.0 L of distilled water. The experimental samples from these groups were taken in a time dependent fashion: 1, 7, 11, 15, 19, 22, 29 days after the start of cultivation.

Experiment B. Bacterial cells of *Arthrobacter* sp. 61B were grown aerobically in 250-mL Erlenmeyer flasks as a 100-ml suspension in TSB broth (Sigma) at $21^\circ C$. The cells were grown with a constant shaking (at a speed of 100rpm). The

experiments were carried out on the following groups of bacteria: 1. Cells with addition of $7.1 \mu g/ml$ $Cr(III)$; 2. Cells with addition of $7.1 \mu g/ml$ $Cr(III)$ + $400 \mu g/ml$ $Mg(II)$; 3. Cells with addition of $7.1 \mu g/ml$ $Cr(III)$ + $400 \mu g/ml$ of K ; Elements $Cr(III)$, $Mg(II)$ and K were added simultaneously to the bacterial cell cultures at this stage as $CrCl_3$, KCl , $MgCl_2$ respectively. The experimental samples from these groups were taken in a time dependent fashion: 16, 24, 48, 96, 144 hours after the start of cultivation. Bacterial culture growth, proceeded without medium renewal.

Evaluation of $Cr(VI)$ resistance

Culture growth was monitored by measuring optical density at 490 and 590nm. The viability was detected by cell growth on agar plates with a cell suspension dilution. Bacterial resistance against $Cr(VI)$ was detected by counting of the Colony Forming Units on metal containing agar plates and measuring the weight of bacterial cells biomass before AAS measurements.

After growing, bacterial cells were harvested from the nutrient medium by centrifugation (3,000g, 15 min, $4^\circ C$), rinsed twice in a Phosphate buffered saline (PBS) and samples prepared atomic absorption spectroscopy (AAS) analysis.

AAS measurements

For the determination of the concentrations of Cr , K and $Mg(II)$ by bacteria itself, wet biomass of bacterial pellet (after centrifugation and washing procedures) was placed in an adsorption-condensation lyophilizer and dried following the procedure reported in [8, 9]. Dried cells were ashed in nitric acid, diluted with bi-distilled water and analysed by AAS method in an acetylene air flame. Analyst 800 (Perkin Elmer) was used. The detection was carried out at 357.9 nm for Cr , at 766.49 nm for K and at 285.2 nm for $Mg(II)$.

The determination of concentration of reduced $Cr(III)$

The reduction of $Cr(VI)$ to $Cr(III)$ was measured by AAS method, according to the method described in US patent # 7148068 [10]. The method is disclosed for determining the concentration of trivalent chromium $Cr(III)$ in a sample. The addition of perchloric acid has been found to

increase the atomic chromium spectrometric signal due to Cr(III), while leaving the signal due to hexavalent chromium Cr(VI) unchanged. This enabled determination of the Cr(III) concentration without pre-concentration or pre-separation from chromium of other valences.

Results and Discussion

To examine the reaction between Cr(VI) and *Arthrobacter oxydans*, together with K and Mg(II),

AAS measurements were carried out. The data of the behavior of K, Cr(VI), and Mg(II) uptake by living *Arthrobacter oxydans* differs with different metal reactions (Fig.1). The Mg(II) concentration in *Arthrobacter oxydans* remained almost constant with reaction time. The behaviour of K and Cr differs during the reaction time.

The Cr(III) and Cr in *Arthrobacter oxydans* increased with Cr(VI) reduction time. Bacteria is able to reduce Cr(VI) into Cr(III) and its reduction

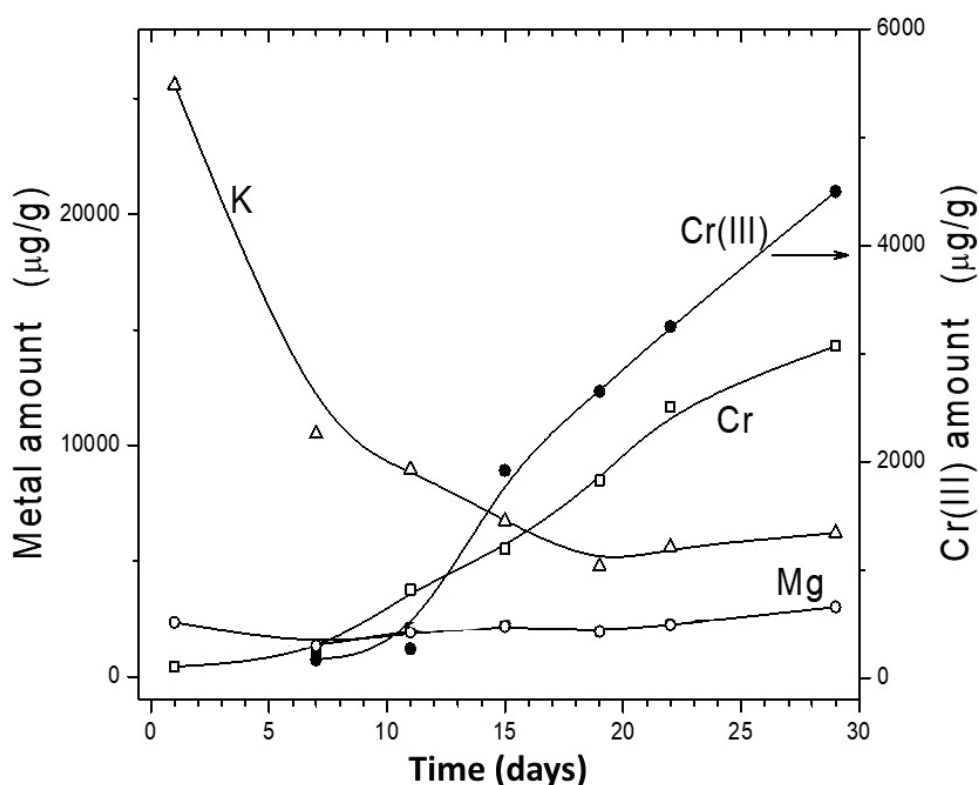


Fig.1. Uptake of K, Cr, and Mg(II) by *Arthrobacter oxydans* grown in the nutrient medium containing Cr(VI) ($70\mu\text{g/ml}$ in the form of K_2CrO_4), $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ (0.2g/l), and K_2HPO_4 (2g/l). X axis denotes the time of metal action on bacterial cell cultures. Y axis on left denotes the concentration on Mg(II), total Cr and K in the cells of *Arthrobacter oxydans*. Y axis on right part of figure denotes the concentration of Cr(III). Cr(III) in the samples appears after 7 days inoculation of bacterial cells with Cr(VI)

starts from 1st day. And Cr(III) concentration reaches its maximum level when reaction time equals at 25th day. In contrast, the concentration of K in *Arthrobacter oxydans* is decreased with Cr(VI) reaction time. The rates of Cr(III) and Cr uptake by cells increased when the K concentration was low. Initially the cellular uptake of Cr(III) and Cr were slow. They both increased suddenly, when reaction time was about 11th days as the amount of K in cells approaching its

minimum. Cr(III) content by AAS was measured according to the method described here [10]. As K level inside the bacterial cells, is very high in the beginning of cultivation, we suggest that its initial high concentration is bacteria's defensive reaction against elevated concentration of toxic Cr(VI) (Fig. 1). In the second experiment we decided to observe the uptake process of Cr(III) by *Arthrobacter* sp.61B from growth medium under the influence of $400\mu\text{g/ml}$ K and Mg(II) (Fig. 2a and 2b)

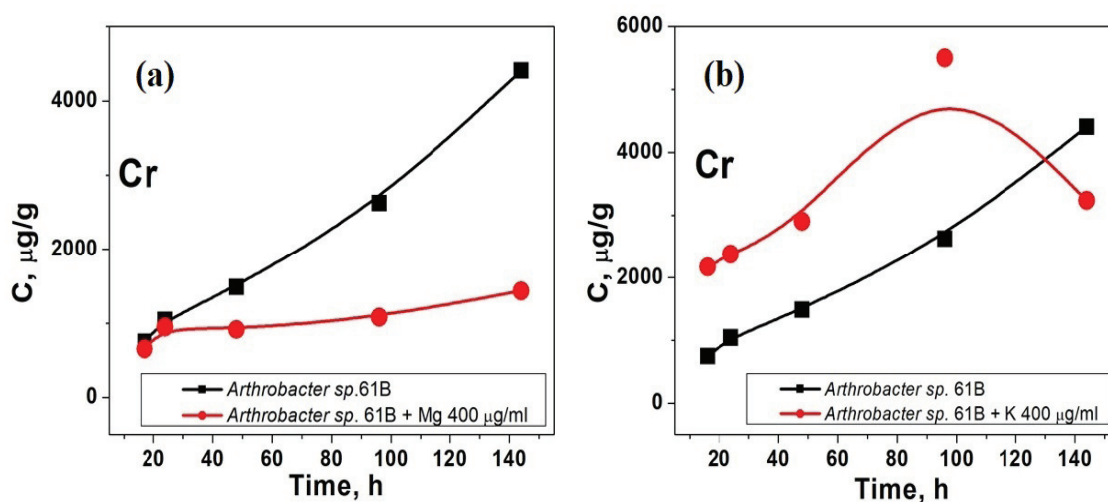


Fig. 2. Uptake of Cr(III) by *Arthrobacter sp. 61B* when 400 µg/ml Mg(II) is added in growth medium (a) and when 400 µg/ml K⁺ is added in growth medium (b). The growth medium contains 7.1 µg/ml Cr(III)

It is revealed, that addition of Mg(II) ions, decreases Cr(III) uptake capability by bacteria and after its exposure with Mg(II) restricts the increase of Cr(III) accumulation by cells. *Arthrobacter sp. 61B* without addition of Mg(II) salt, effectively accumulates Cr(III), and its concentration increases with time. Opposite figure is obtained under the influence of 400 µg/ml of K action in the growth medium: at every time point about 1000 µg/g higher is the Cr(III) concentration in K treated cells. We

can suggest that, K helps in Cr(III) accumulation. The exception is last, 140h time point, when Cr(III) concentration is lower in K treated cells than in control one. Following tendencies are observed on the biomasses of bacteria under the K action: Biomasses of the cells which were grown with or without 400 µg/ml of K do not differ from each other. And 400 µg/ml of Mg(II) increases biomass of *Arthrobacter sp. 61B* at 96h and 144h.

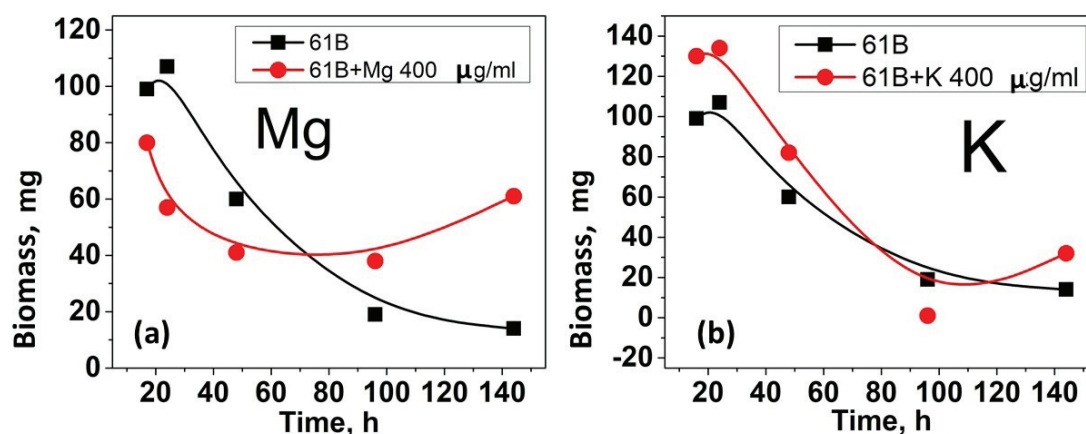


Fig. 3. The influence of Mg(II) (a) and the influence of K (b) on the biomasses of *Arthrobacter sp. 61B*

Conclusion

In bacteria isolated from polluted basalts in Georgia *Arthrobacter sp. 61B* and *Arthrobacter oxydans*, which is isolated from Columbia basalt rocks originated from a highly contaminated site in

the USA we studied: (1) the uptake process of Cr(VI) and Cr(III) with the presence of K and Mg(II). Experiments revealed that the content of Cr(III) in the bacteria of *Arthrobacter oxydans* increases with the time of growth. Hence, *Arthrobacter*

oxydans can be used for effectively removing toxic Cr(VI) from the environment. The uptake of Cr(III) from growth medium by *Arthrobacter* sp. 61B was enhanced by the presence of 400 µg/ml K. Mg(II) ions with the same concentrations affected the accumulation of Cr(III) by *Arthrobacter* sp. 61B. It is shown that the uptake of Cr(VI), its accumulation and reduction to Cr(III) form by bacteria of *Arthrobacter oxydans* continues during the entire period of the experiment without saturation. According to the data, *Arthrobacter oxydans* can be used for effectively removing toxic Cr(VI) from the environment. Besides, it was shown that the uptake of K reaches the maximum quantity in the beginning of experiment after one day, bacteria begin its' efflux from the cell.

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Conflict of Interests

The authors declare no conflict of interest.

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Influence of the wheat seeding dates on the biometric indicators in the climatic condition of Samtskhe-Javakheti

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ABSTRACT

The impact of climate change on the entire plant development chain has not been fully assessed so far; however, some aspects of this process have been affected by climate change and adaptation measures have been prepared [1]. Due to the impact of climate change (early frosts, weak plant growth), it is important to determine the optimal timing of wheat sowing in the Samtskhe-Javakheti region. For this purpose, surveys were conducted in 2018-2019. According to the results of our studies in the region of Samtskhe-Javakheti, the timing of wheat sowing has changed as a result of climate change. The previous sowing dates were moved forward by around two weeks. According to our data, the optimal sowing period is from October 1 to October 15. Wheat sown during this period precedes normal development in autumn. It overwinters easily, can withstand frosts in spring and blooms well. The plant grows strongly and yields a high-quality crop.

Keywords: Wheat, Variety, Seeding terms, Frost-resistant, Drought, Biometric indicator.

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Introduction

Interaction of a human and a climate is the major problem at this stage of mankind's development and it can become the reason either for progress or regress of the society. It is noticeable especially in the highland countries, like Georgia.

Samtskhe-Javakheti is one of the most important regions distinguished due to the above-mentioned problem in Georgia located in the south-west of the country and having different climatic conditions compared to other regions of Georgia. It can be explained by the influence of location. There are a series of differences including temperature, climate conditions in Samtskhe-Javakheti, mainly related to geographical location and complicated landscape, radiation regime, dominant atmosphere general and local circulation conditions. According to the meteorological observations, we can conclude that a dramatic change in average temperature takes place in Samtskhe-Javakheti, the cases of warming and cooling were registered [2].

Climatic conditions are diversified in Samtskhe-Javakheti. It is characterized by moderate precipitation, dramatically expressed seasonal changes in climate parameters and a high level of solar radiation. Samtskhe and Javakheti differ from each other very much. Samtskhe is characterized by a moderately dry, sub-tropic mountainous climate with a little snowy winter and long, cool summer [3].

Winter wheat is the main cereal crop in the Samtskhe-Javakheti region. Wheat is grown mainly in non-irrigated land and the drought of autumn and spring affects it mostly. The negative impact of the drought is evident after seeding, during spring, and after seed enlargement. Therefore, agricultural terms have crucial importance during in growing technology of winter wheat. Plant growth and development depend on agrometeorological conditions, resistance to the high and low temperature, diseases, and pests, finally influencing the yield and biometric indicators of wheat. The winter without snow often is the problem for winterization of the winter wheat. In case a

plant has 4-6 leaves with completed growth and it is quite bushy, it can winterize well, it is supported by the proper amount of nutritional elements. In case the plants are planted during a non-optimal period and are overgrown, it will not be resistant towards the long-term frosts in winter; it will cause loss of yield. Late seeding also influences the yield rate and biometric indicators of the plant, as the latter is not able to develop properly and meets winter weakly developed [4].

One of the key weaknesses of Agriculture in the Samtskhe-Javakheti region is a limiting factor of agro-climatic resources. In particular, short-vegetation period, therefore, selection of winter and frost-resistant varieties for the season, defining the optimal terms for seeding to support overwintering of the crop and guaranteed yield [5].

Methodology and materials

The goal of the research was to define seeding terms and their influence on the plant biometric data and harvesting rate.

In order to define the optimal sowing dates the seeding took place for four terms in 2018 and 2019:

The first term - Seeding 20/09, seeding norms 4 millions seeds capable to grow per 1ha;

The second term - 01/10, seeding norms 4 millions seeds capable to grow per 1ha;

The third term - 10/10, seeding norms 4 millions seeds capable to grow per 1ha;

The fourth term - 20/10, seeding norms 4 millions seeds capable to grow per 1ha.

During the vegetation period, the phenological observations took place using the UPOV (The International Union for the Protection of New Varieties of Plants) method. After harvesting the sample plants were taken from each norm and their biometric indicators were studied.

For defining an optimal period of sowing, the factors studied are the duration of the phenological phases and general vegetation period, the viability of wheat varieties in each term of seeding (germination of the seed, survival of the germinated plant, (winterization capacity), the offshooting rate of the plants, the height of the plant, resistance to the diseases, the length of the spike, the number of fertile and sterile spikes, the number and the weight of the seed in spike, the weight of one plant and 1000 seed, the number of productive tillers per plant, the weight of the seed per the unit.

The total yield per ha for each sample of the

trial was measured. The sample from each variety, the so-called square, was taken for defining productivity. One square was taken from each part, which was marked after the completion of the germination phase. The number of the plants and the number of the productive tillers and productivity of the seed (in gr) were defined per each square on the unit (1m²).

The following three varieties of the wheat were used in each planting term Akhaltsikhis tsiteli dolis puri (*Triticum aestivum* var. *ferrugineum*), Tbilisi 15 and Sauli 9. Seeding was repeated 3 times. The planting took place in one day during each term of planting. The observation area for each sample of planting was 25m². The quantitative data received were processed by the arithmetical statistical method [6].

Results and Analysis

In 2018-2019 the research was conducted based on the above-described methodology. During the entire vegetation period, plant development was observed according to the pheno-phases and seeding terms. The total data received during the research are summarized in **table 1**.

According to the data analysis, the second and the third terms (from October 1 to October 15) are the most effective and optimal period for seeding wheat in the climatic condition of Akhaltsikhe, as the plant can develop several leaves (4-6) and winterize properly. The length of the spike is higher in the second and third terms, as well as the seed number and consequently, the weight of the seed is more in the second and the third terms. In the case of early seeding, the plant is developed better, the plant height is more and in most cases, it causes plant lodging and therefore it is not resistant to the long winter frost.

As the observation shows, the early frost cases are very often in the Samtskhe-Javakheti region and it causes loss of wheat yield. In case of late seeding the plant is not able to grow properly and is unable to overcome the winter frost, the number and weight of the seeds in the spike are reducing and affects productivity of the crop. A significant deviation in either direction (too early or too late) has a negative impact on the crop. This is why the selection of the relevant seeding period is crucial for seed quality and productivity considering the region's climate specification.

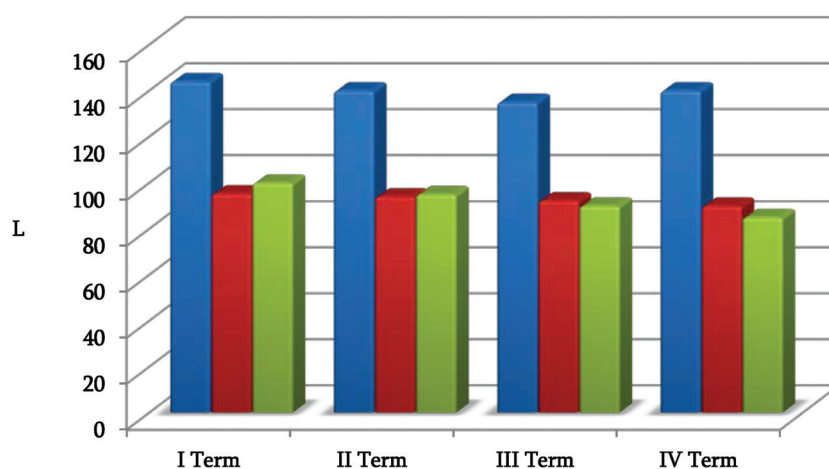
Conclusion

The results of the data analysis demonstrated the influence of each version on the intensity of the plant

Table 1. Influence of the winter wheat seeding terms on biometric characteristics of the plant (2018-2019)

The key findings of the research are given in the form of graphics (Fig. 1-4).

Variety	Seeding norm, mln /ha	Number o plants (main characteristics), per 1m ²								
		Plant height, cm	breeding		Length of spike, cm	amount of wheat head		The number of seed in the spike, each	One seed, weight, gt	The length of seeds in the spike, gr
			Productive	Non-productive		Developed	Non-developed			
Akhalsikhe Red Dolly, I term	4	144.0	8.0	0.5	8.5	16.0	1.0	30.0	1.33	39.9
Akhalsikhe Red Dolly, II term	4	140.0	8.5	0.5	9.2	18.0	0.5	35.0	1.33	46.55
Akhalsikhe Red Dolly,III term	4	135.0	9.5	-	9.0	18.0	1.0	34.0	1.35	45.9
Akhalsikhe Red Dolly, IV term	4	140.0	8.5	1.5	8.2	14.0	1.0	26.0	1.30	33.8
Tbilisi 15, I term	4	95.3	7.0	0.5	10.0	14.5	1.2	27.0	1.13	30.51
Tbilisi 15, II term	4	94.0	6.2	-	11.0	15.5	0.2	31.1	1.15	35.8
Tbilisi 15, III term	4	92.3	6.0	0.2	11.5	15.0	1.0	28.0	1.16	32.48
Tbilisi 15, IV term	4	90.0	5.0	0.2	11.0	14.0	1.2	27.0	1.13	30.51
Sauli 9, I term	4	100.0	8.0	0.5	11.0	22.0	2.0	40.0	2.05	82.0
Sauli 9, II term	4	95.0	6.0	0.3	13.0	24.0	1.0	46.0	2.25	103.5
Sauli 9, III term	4	90.0	7.0	0.1	12.0	22.0	-	45.0	2.20	99.0
Sauli 9, IV term	4	85.0	6.0	0.6	9.0	18.0	2.0	32.0	2.10	67.2

**Fig. 1.** L -The height of the trial wheat variety (cm) according to the seed terms per 1m²

Akhalsikhe Red Dolly ■ Tbilisi15 ■ Sauli9 ■

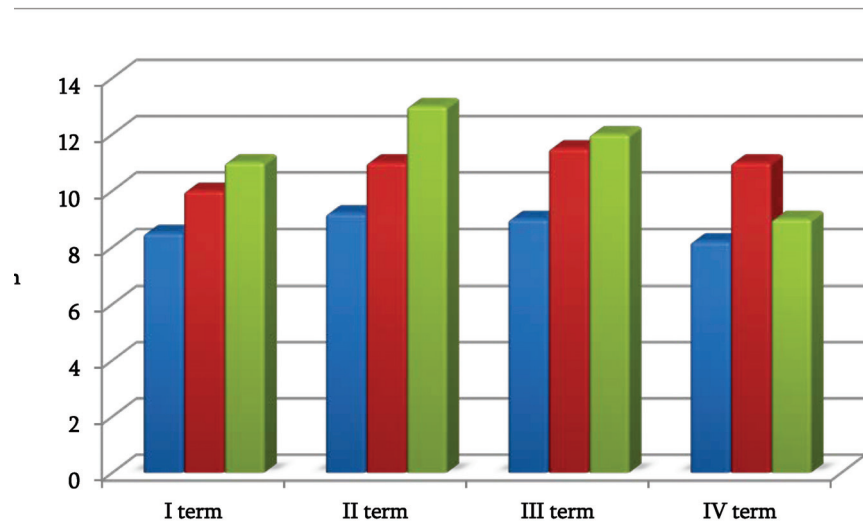


Fig. 2. The spike length (cm) per research wheat variety according to the seeding terms on 1m²

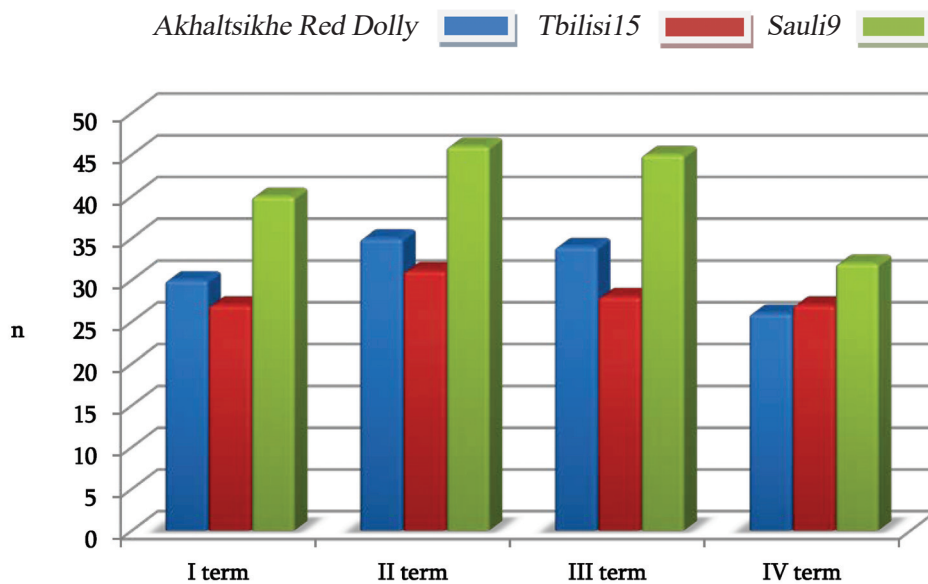


Fig. 3. Seed number per ear of the research wheat variety according to the seeding terms on 1m²

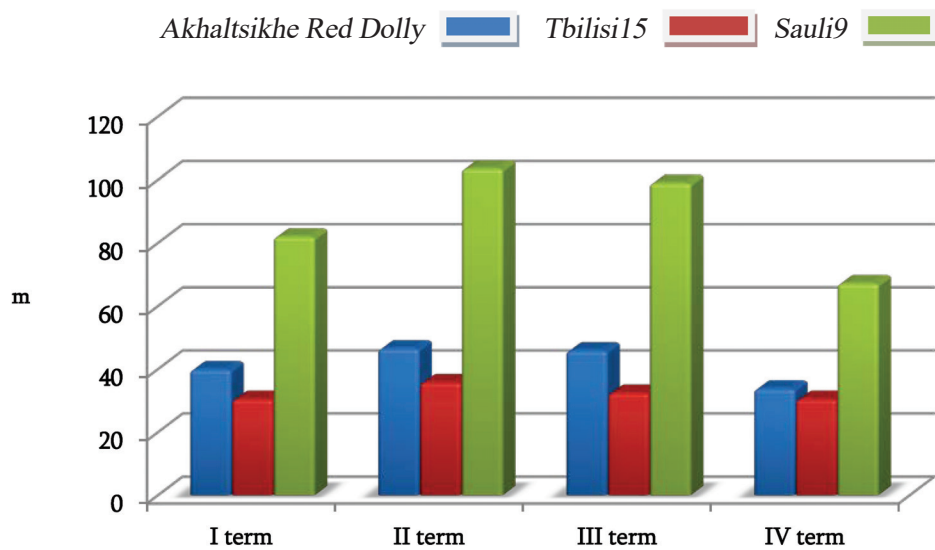


Fig. 4. Seed weight (in grams) per spike of the research wheat variety according to the seeding terms on 1m²

Akhaltsikhe Red Dolly Tbilisi15 Sauli9

growth and development and develop recommendations for defining optimal periods for seeding.

As a result of the conducted research, it was found that: In Samtskhe-Javakheti, the optimal period of the wheat seeding was changed;

The previously known dates of sowing were moved forward by around two weeks;

According to our data, the optimal period is from October 1 to October 15.

The wheat seeded during this period is able to grow normally, it winterizes easily, is resistant to the spring frost, it offshoots well; the plant is developed strongly and gives high and quality yield.

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On the issue of industrial use of *Rhododendron caucasicum* Pall. and *Rhododendron ponticum* L.

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ABSTRACT

The article shows that due to their rich biochemical compositions, *Rhododendron caucasicum* Pall. and *Rhododendron ponticum* L. which are widespread in mountain regions of Georgia, can be widely used in medicine, perfumery, ornamental gardening, furniture and leather production. These species are the tertiary relicts, prevent soil erosion and, simultaneously, can be used for avalanche protection purposes. As is known, the attention being paid to plants is increasing daily, and the main source of their production is wild populations, which destroys the invaluable natural treasures - plants that are distinguished both for therapeutic and decorative benefits. Thus to avoid anthropogenic impacts and uncontrolled collection of plants, it is possible to grow the usable plants.

Keywords: Relict, Biochemical composition, Soil erosion, Cultivation, Plant, Industrial use.

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Introduction

In today's world, consumption of food and medicinal plants has been increasing steadily. Today, chemicals are no longer regarded as the sole agent for treating diseases and life extension. The public is now convinced that any chemical drug has usually certain counterindications. That is why today there is a search for possibilities for using different medicinal plants. Modern scholarly research had shown that there is a lot of plants on earth that can be used for both food and medicinal purposes. Pharmacologists, chemists, biochemists and botanists are working on a scientific research to discover new medicinal properties of plants, and to use them in production of environmentally friendly multicomponent therapeutic food products and medicinal agents that ensure timely and full removal of harmful substances and heavy metals deposits from the human body [1].

In this regard, *Rhododendron caucasicum* Pall and *Rhododendron ponticum* L [2-7] that are some-

what common in Georgia and are viewed as promising plant species, deserve more attention [8].

In the Caucasus, the altitudinal area of their complex coincides with the highland meadows (subalpine, alpine) and includes altitudes of 1800-2800 m. However, it is not uncommon for *Rhododendron caucasicum* Pall to reach altitudes of 3000-3100 m in massive mountain ranges. In subalpine zones, along with *Rhododendron caucasicum* Pall, the creation of its cenosis involves also *Vaccinium myrtillus* L, *Empetrum caucasicum* Juz. *Ribes alpinum* L, etc.

Rhododendron caucasicum Pall grows to 160-300 m tall, in the subalpine zone (in birch woods and beech forests), which forms a very tight undergrowth, while in the alpine zone, it forms a thicket on the northern slopes, while *Rhododendron ponticum* L grows from sea level up to the middle forest belt, which sometimes reaches the subalpine zone.

In western Georgia, the *Rhododendron ponticum* L cenosis is clearly visible up to 1000-1100 m

above sea level, which was formed from plants such as *Rhododendron caucasicum* Pall, *Rhododendron unguernii* Trautv., *Vaccinium arctostaphylos* L, *Laurorassus officinalis* Roem, *Viburnum orientale* Pall, *Hedera colchica*(K.Koch) K.Koch, etc.

The herbaceous cover is not rich because shrubbery is quite dense and covers soil. Despite the soil cover, ferns and some cereals are also found.

basic part

It has been established that the use of both *Rhododendron caucasicum* Pall and *Rhododendron ponticum* L containing large amounts of tannins, is promising for human health. Growth of the shoots

of the first plant starts in April and ends in mid-June. The leaves also grow at this time. The development of leaves of the second plant begins in May or June; these leaves will overwinter twice, while the third plant decays in late summer they are deciduous.

According to literary sources [8, 9], the elements identified as a result of biochemical studies on the leaves of *Rhododendron Caucasicum* Pall and *Rhododendron Ponticum* L are presented in Table 1.

Data obtained as a result of studying the compositions of catechins, leucoanthocyanins and flavonols in different organs of both plants (Table 2) show that the flavonoid contents in different organs of one plant, as well as their contents in the same organs of other plants are different.

Table 1. Identified elements from *Rhododendron caucasicum* and *Rhododendron ponticum*

Name of plant	(+)-catechin	(-)-epicatechin	(+)-gallo catechin	Leucopeonidin	Leucopetunidin	Hyperin	Avicularin	Myricetin	Leucocyanidin	Leucodelphinidin	Quercitrin	Quercetine	Isoquercitrin
<i>Rhododendron caucasicum</i>	+	+	+	+	+	+	+	+	+	+	+		
<i>Rhododendron ponticum</i>	+	+	+						+	+	+	+	+

The dynamics of accumulation of catechins, leucoanthocyanidins and flavonols in the leaves of both plants during the vegetation process has also been

analyzed by scientists, the total values of which are presented in Fig.

Table 2. Flavonoid content (mg 1 g on dry weight basis) in different organs of *Rhododendron caucasicum* and *Rhododendron ponticum*

Research subject	Picking time	Catechin	Leucoanthocyanidins	Flavonols	Total
Rhododendron caucasicum					
Vegetative buds	May	42,2	258,7	27,8	328,7
Summer leaf	August	24	147,8	12,9	184,7
Two-year leaf	August	34,5	206,2	33,7	274,4
Three-year leaf	August	35,4	190,1	52	277,5
Sprouts	August	16,8	105,3	6,5	128,6
Stems	August	1,7	21,9	3,7	27,3
Roots	August	11	82,6	6,4	100
Generative buds	May	22	185,6	19,7	227,3
Rhododendron ponticum					
Leaves	August	17,3	104,4	6,4	128,1
Sprouts	August	11,2	75,4	5,6	82,2
Stems	June	2,4	16,2	4,2	22,8
Roots	June	9,4	73,9	5,9	89,2
Buds	June	15,3	76,1	13,2	104,6

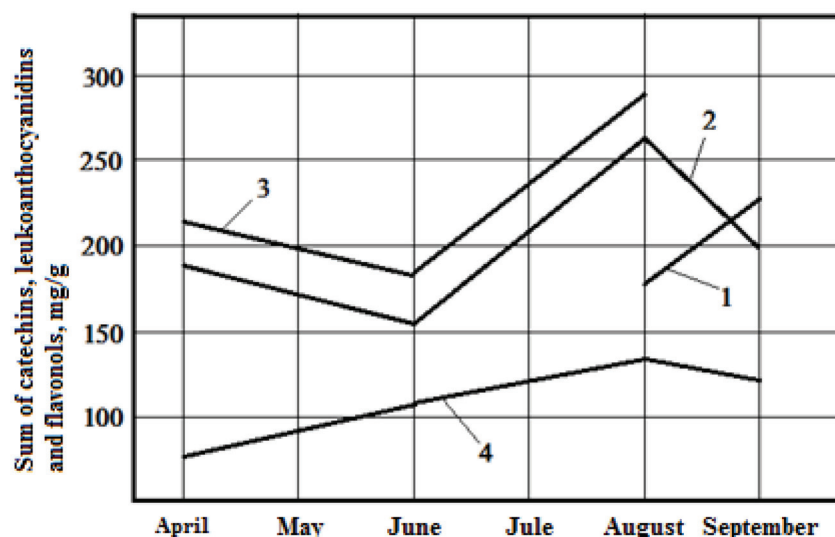


Fig. Variations of flavonoids totals during the vegetation process

Rhododendron caucasicum Pall leaves: 1- summer, 2- two-year, 3- three-year, 4- *Rhododendron ponticum* L leaves

As can be seen in this Figure, the number of these elements depends on the time for the beginning and end of vegetation, as well as on the flowering period. Finally, it has been concluded that the amount of tannins in the leaves of *Rhododendron caucasicum* Pall. and *Rhododendron ponticum* L increases during summer and decreases in the autumn.

All the elements in the compositions of these plants have medicinal properties, except for glycoside and romedotoxin, which is a powerful organic poison. So, attention should be paid to the amount of *Rhododendron caucasicum* Pall. taken by humans. However, in the case of recommended daily intake (one cup of tincture per day) *Rhododendron caucasicum* Pall. is completely harmless.

A brief description of their rich chemical compositions that we provided clearly demonstrates its multiple positive impacts on human health. It is the mentioned chemical composition that leads to its widespread use [10-12] in the treatment of diseases such as cardiovascular problems, viral infections, rheumatism, colitis, vegetative neuroses, female infertility, pelvic inflammatory disease, as well as removal of toxins and heavy elements from the body, as well as strengthening the body's immune system.

The plant is also characterized by anti-lipase properties. Its roots contain substances that reduce the body's ability to absorb fats and, in besides, they help to burn fats existing in the body.

In addition to medicine, *Rhododendron caucasicum* Pall. and *Rhododendron ponticum* L are also

used in perfumery, ornamental gardening, as well as in manufacture of furniture and leather.

For the development of today's economy of Georgia, it is important to revive various sectors of the economy, as well as to start manufacture of new products that are important for the country. These might include *Rhododendron caucasicum* Pall.

Due to a multiplicity of its useful properties, it is possible to produce numerous types of medicines, ointments, tinctures essential for human health and life extension, which will be sold both domestically and abroad. This will provide a window for opportunity to contribute significantly to the country's economy. In addition, there are job opportunities for people in the mountainous regions of Georgia, and thus for improving their living conditions.

An example of this in Georgia could be provided by the enterprise for processing *Rhododendron caucasicum* Pall. and *Rhododendron ponticum* L established in 2016 in the village Barisakho with a grant from the Rural Community Development Agency, which aims to produce and sell tea with mixed different wild-growing plants.

However, such an important issue should not be realized through the deterioration of the ecological status of mountainous regions.

Rhododendron caucasicum Pall. and *Rhododendron ponticum* L are the anti-erosion shrubby plants growing on the mountain slopes. Its stems that are far-flung on the ground play an important role in avalanche prevention. All this suggests us the need

for rational use of this evergreen shrubby plant [13].

In the case of picking permissible specified quantities of leaves, it is possible to avoid any damage to the environment and, at the same time, to manufacture products that have very beneficial effects for human health, to market them both locally and internationally.

In the context of maintaining the ecological status of high mountain regions, an alternative way to increase their raw materials base is to grow this plant in the regions of Georgia, where the very harsh winter conditions do not allow the cultivation of other agricultural crops.

It is generally believed that they cannot easily be grown. However, there are many species of cultivated plant, whose needs differ significantly from those growing in the wilderness (Table 2). In various countries, the plant has been well adapted to a tough nature, changes in relative air humidity, is not

very demanding for soil acidity and withstands the impact of urban pollution; it also does not necessarily require the slopes in the highlands zone, and so on. [14-16].

Based on the above, it can be considered that these plants can be grown in the regions of Georgia where it is not possible or profitable to grow other plants due to local conditions (low temperature, high humidity, steep mountain slopes, etc.). In case of successful cultivation of the plant, the region will be beautified with ornamental plants, the soil will be protected from erosion, the amount of plant raw materials beneficial for human health will be increased and the possibility of its industrial extraction will be realized. At the same time, edible-drug raw materials obtained from the plant can be sold both inside the country and abroad, which will have a positive impact on the country's economy.

Table 3. Truncation data on the Caucasus mountain bushes

Countries	Species			
	Rhododendron Caucasicum	Rhododendron ponticum	Rhododendron Smirnovii	Rhododendron Ungeri
USA				+
Great Britain	+	+	+	+
Germany	+	+	+	+
France		+	+	
Italy		+	+	
Belgium		+	+	
Poland			+	
Czech Republic	+		+	
Netherlands		+		
Sweden			+	
Austria	+	+	+	+
Denmark		+	+	
Norway			+	
Japan		+		

It should be taken into consideration that it is necessary to avoid the loss of the useful biochemical properties of plant grown in new places, which would require relevant scientific research.

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Conclusion

1. The use of *Rhododendron caucasicum* Pall. and *Rhododendron ponticum* L. can offer tangible benefits in terms of both health improvement and the country's economic development;

2. In order to prevent ecosystem degradation in mountain regions, it is necessary to ensure specified and selective picking of leaves and flowers of the plant;

3. *Rhododendron caucasicum* Pall. and the use of *Rhododendron ponticum* L. can bring great benefits both for the improvement of human health and for the economic development of the country;

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New species of gasteroid fungi for Georgia's mycobiota

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ABSTRACT

Nineteen species of gasteroid fungi of 10 genera and six families were recorded in steppe and semi-desert habitats of Georgia, the South Caucasus, in 2019 within the framework of a research project “Dryland cryptogams of Georgia: diversity, conservation and potential as bioindicators of desertification” supported by Shota Rustaveli National Science Foundation. Five species: *Cyathus stercoreus* (Schwein.) De Toni, *Disciseda bovisia* (Klotzsch) Henn., *Gaštrosporium simplex* Mattir., *Geaštrum floriforme* Vittad. and *Geaštrum xerophilum* Long ex Desjardin are new for Georgia's mycobiota.

Keywords: Agaricomycetes, Gasteromycetes, Biodiversity, Drylands, Kvernakebi, Gareji.

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Introduction

Gasteroid fungi (Gasteromycetes) is a group in the phylum Basidiomycota with basidiospores developing in angiocarps, fruitbodies closed until basidiospore maturation. Species of this group are mainly terrestrial, epigeous or nypogeous, partly saprobic and partly ectomycorrhizal; they are cosmopolitan, occurring especially in warm dry areas [1]. The first comparatively large (28 species) of Georgia's gasteroid fungi was included in a work by Voronov [2]. Data on separate species are given in works by Haussknecht [3], Voronov [4], Voronikhin [5, 6], Singer [7], Vasilkov [8], Kreisel [9], Jorjadze [10-12] and annual reports of the Department of spore-producing plants and fungi of the Institute of Botany, Ilia State University, Tbilisi, Georgia. The first annotated checklist of Georgia's gasteroid fungi was published by Nakhutsrishvili in 1972 and later in 1982 with 53 species recorded throughout the country [13, 14].

Materials & Methods

Study area

The study area covers parts of the major distribution range of Georgia's semi-arid open forests of *Pistacia mutica* Fisch. & C.A. Mey. and *Juniper* spp., scrub constituted by various hemi-xerophilic species with predominance of *Paliurus spina-christi* Mill., various steppe communities mostly made up of *Botriochloa ischaemum* (L.) Keng, semi-desert vegetation dominated by *Artemisia lerchiana* Weber and a number of transitional and mixed communities [15, 16]; it particularly includes southern slopes and foothills of the Kvernakebi low range along the left banks of the river Mtkvari (Kura), and Gareji and Taribana drylands on the Iori plateau. The 70 km long Kvernakebi range stretches along the left bank of Mtrkvari from the river Sakashetiskhevi to the west reaching the river Aragvi to the east. The 170 km long and 50-60 km wide Iori plateau is stretched from the northwest to the southeast between the rivers Mtkvari and Alazani. The elevations within the study area mostly

range from 300 m (Chachuna Sanctuary) to 750 m (Garedji area) but in places reach 800 m a.s.l. Conglomerates, sandstone, clay and in places limestone shape the geological profile [17-19].

The mean annual temperature of the semi-arid areas of the eastern Caucasus is 12-13°C. Summer is very warm with the mean monthly temperature of July between 22-24°C; winter is mild as on the major portion of the East Georgian territory with the main temperature of January ranging between - 4°C and 4°C. The average annual precipitation ranges between 400-600 mm; precipitation decreases to the east being the lowest on Iori plateau. The major portion of the annual precipitation falls in spring and summer in a form of the heavy downpours. Precipitation is the lowest in winter months with unstable snow cover, which is in some years absent [18, 20].

Specimen collection and identification

Fruitbodies of gasteroid fungi were collected in various semi-arid habitats of east Georgia from June to December, 2019. Carpophores and habitats were photographed for each collection using Nikon Coolpix L830. Geographic coordinates were recorded for each locality Garmin Etrex 20. Habitat characteristics: slope exposure and inclination, plant cover; and substrate were also recorded.

Species were identified and stored at the Herbarium of the Department of spore-producing plants and fungi of the Institute of Botany of Ilia State University (at the Cryptogam Herbarium, which is a part of the National Herbarium of Georgia, TBI). Melzer's iodine reagent or 5% KOH was used for treatment of small sections of gleba for microscopical examination Olympus CX31RBSF binocular microscope. Various keys were used for species identification [21-26, etc.].

Fungi nomenclature follows Index Fungorum [27]. Vascular plant nomenclature in the short descriptions of examined habitats follow Gviniashvili et al. [28].

Results & Discussion

Nineteen species of gasteroid fungi of 10 genera and six families were recorded in steppe and semi-desert habitats of Georgia, the South Caucasus, in 2019 within the framework of a research project "Dryland cryptogams of Georgia: diversity, conservation and potential as bioindicators of desertification" supported by Shota Rustaveli National Science Foundation. The genus *Geastrum* was the most di-

verse with six species recorded.

The most abundant were fruitbodies of *Disciseda bovista* (Klotzsch) Henn., *Disciseda candida* (Schwein.) Lloyd, *Tulostoma brumale* Pers. and *Tulostoma fimbriatum* Fr. It is noteworthy that eighteen fruitbodies of *T. fimbriatum* were collected in a single open place on 35 cm² area among *Paliurus spina-christi* shrubs in the Kotsakhuri dry gorge on the Kvernakebi study area.

Chlorophyllum agaricoides (Czern.) Vellinga and *Tulostoma volvulatum* I.G. Borshch. Were found in every of the three study areas (Kvernakebi, Gareji and Taribana).

Five species: *Cyathus stercoreus* (Schwein.) De Toni, *Disciseda bovista* (Klotzsch) Henn., *Gastrosporium simplex* Mattir., *Geastrum floriforme* Vittad. and *Geastrum xerophilum* Long ex Desjardin are new for Georgia's mycobiota.

Below a list of the recorded species is given: families, genera and species are listed in alphabetic order. Locality, habitat, substrate, collection date and collector name are given for the species recorded. Specimen descriptions are given for the species new for Georgia's mycobiota.

Agaricaceae Chevall

Disciseda bovista (Klotzsch) Henn., Hedwigia 42 (Beibl.): (128) (1903) (Fig. 1a)

Fruitbody spherical or depressed spherical to discoid, 1-5 cm diam. Exoperidium thick, with break-ages, at maturity cracks into two unequal parts, the upper part disappears, the lower one remains in as a disc encrusted with soil and plant debris. Endoperidium spherical 1-3.5 cm diam., leathery, smooth, persistent, at first greyish, later brown, opens at tip with a single ostiole. Gleba at first white, dense, later brown and pulverulent. Spores globose, 6-8 µm diam., verrucose, brownish, with or without short sterigmal remnants.

Habitat: On sandy soil.

Material examined: Near David Gareji Monastery, Sagarejo Municipality, 600 m a.s.l., N45.3765 E41.4532, 11.11.2019, A. Jorjadze, TBI5022821; Uplistsikhe, near old cemetery, Gori Municipality, 615 m a.s.l., N41.9718 E44.2043, 25.09.2019, A. Jorjadze, TBI5022817.

Geographic distribution: Argentina, Armenia, Australia, Austria, Czech, Denmark, France, Germany, Holland, Hungary, India, Iran, Israel, Italy, Kazakhstan, Mongolia, Netherlands, New Zealand, Norway, Poland, Republic, Romania, Russia, Slo-

vakia, Spain, Sweden, Switzerland, Turkmenistan, Ukraine; North and Southern Africa [9, 23, 29, 30].

Notes: *Disciseda bovista* is morphologically similar to *Disciseda candida*, but is characterized by larger and strongly ornamented spores [31].

***Disciseda candida* (Schwein.) Lloyd, Mycol. Writ. 1: 100 (1902) (Fig. 1b)**

Material examined: On sandy soil, steppe community, everywhere, scattered, Gareji dryland, Sagarejo Municipality, 800 m a.s.l., N45.3183 E41.4747, 14.10.2019, A. Jorjadze, TBI5022799; on sandy soil, Taribana, Chachuna Sanctuary, Dedoplistskaro Municipality, 360 m a.s.l., N45.9764 E41.2766, 29.10.2019, A. Jorjadze, TBI5022786; on sandy soil, steppe community, Gareji dryland, Sagarejo Municipality, 825 m a.s.l., N45.3483 E41.4842, 19.11.2019, A. Jorjadze, TBI5022820.

Geographic distribution: Armenia, Australia, Austria, Czech Republic, Denmark, France, Germany, Holland, Hungary, India, Iran, Kazakhstan, Lithuania, New Zealand, Norway, Poland, Romania, Russia, Slovakia, Spain, Sweden, Switzerland, Ukraine, United States; South Africa and South America [9, 23, 25, 30, 32, 33].

***Chlorophyllum agaricoides* (Czern.) Vellinga, Mycotaxon 83: 416 (2002) (Fig. 1c)**

Material examined: Near *Salsola* sp., on sandy soil, Kvernakebi Range, Kaspi Municipality, 670 m a.s.l., N41.9672 E44.3374, 14.09.2019, A. Jorjadze, TBI5022797; under *Salsola* sp., on sandy soil, Kvernakebi Range, Kaspi Municipality, 650 m a.s.l., N41.96186 E44.3466, 23.09.2019, A. Jorjadze, TBI5022812; under *Salsola* sp., on sandy soil, Uplistsikhe, near old cemetery, Gori Municipality, 615 m a.s.l., N41.9718 E44.2043, 25.09.2019, A. Jorjadze, TBI5022780; on soil, steppe community, near David Gareji Monastery, Sagarejo Municipality, 600 m a.s.l., N45.37652 E41.4532, 11.11.2019, A. Jorjadze, TBI5022823.

Geographic distribution: Algeria, Armenia, Australia, Austria, Bulgaria, Czech Republic, France, Germany, Hungary, Israel, Italy, Kazakhstan, Kyrgyzstan, Lithuania, Mongolia, New Zealand, Romania, Russia, Slovakia, Sweden, Tajikistan, Turkmenistan, Ukraine, Uzbekistan; South Africa, South America [9, 23, 32, 33].

***Mycenastrum corium* (Guers.) Desv., Annls Sci. Nat., Bot., sér. 2 17: 147 (1842) (Fig. 1d)**

Material examined: On sandy soil, Uplistsikhe, near old cemetery, Gori Municipality, 615 m a.s.l.,

N41.9718 E44.2043, 25.09.2019, A. Jorjadze, TBI5022779.

Geographic distribution: Algeria, Armenia, Austria, Belgium, Bulgaria, Czech Republic, Denmark, Ethiopia, Finland, France, Germany, Hungary, India, Mexico, Israel, Italy, Kazakhstan, Kenya, Kyrgyzstan, Lithuania, New Zealand, Norway, Poland, Romania, Russia, Slovakia, Socotra (Yemen), South African Rep., Spain, Sweden, Tanzania, Netherlands, Tunisia, Turkmenistan, Uganda, Ukraine, United States, Uzbekistan, Zanzibar; Eastern Africa, South America [9, 23, 26, 30, 32-34].

***Tulostoma brumale* Pers., Neues Mag. Bot. 1: 86 (1794) (Fig. 1e)**

Material examined: On sandy soil, Kvernakebi Range, Kaspi Municipality, 670 m a.s.l., N41.9672 E44.3374, 14.09.2019, A. Jorjadze, TBI5022810; among mosses, under *Rhamnus pallasii* Fisch. & C.A.Mey., Uplistsikhe, near old cemetery, Gori Municipality, 615 m a.s.l., N41.9718 E44.2043, 25.09.2019, A. Jorjadze, TBI5022809; among mosses, under *Paliurus spina-christi*, Kotsakhuri dry gorge, Kvernakebi Range, Kaspi Municipality, 600 m a.s.l., N41.9602 E44.3801, 01.12.2019, A. Jorjadze, TBI5022808.

Geographic distribution: Armenia, Austria, Azerbaijan, Belgium, Bulgaria, Czech Republic, Denmark, England, Estonia, Finland, France, Germany, Greece, Hungary, India, Iran, Ireland, Italy, Japan, Kazakhstan, Lithuania, Netherlands, New Zealand, Norway, Poland, Romania, Russia, Slovakia, Spain, Sweden, Switzerland, Tunisia, Turkmenistan, Ukraine; North America [9, 23, 30, 32, 33].

***Tulostoma fimbriatum* Fr., Syst. mycol. (Lundae) 3(1): 43 (1829) (Fig. 1f)**

Material examined: On sandy soil, Kvernakebi Range, Kaspi Municipality, 650 m a.s.l., N41.9621 E44.3462, 23.09.2019, A. Jorjadze, TBI5022808.

Geographic distribution: Argentina, Armenia, Austria, Czech Republic, Denmark, France, Germany, Hungary, Iran, Italy, Kazakhstan, Lithuania, Lithuania, Macedonia, Netherlands, Norway, Poland, Portugal, Romania, Russia, Slovakia, Spain, Sweden, Switzerland, Ukraine; North America [9, 23, 29, 30, 32, 33].

Note: Eighteen carpophores found on area of 35 cm².

***Tulostoma volvulatum* I.G. Borshch., Mat. Bot. Geogr. Aralo-Kaspi Imp. Akad. Nauk. St. Petersburg. 7: 189 (1865) (Fig. 1g)**

Material examined: On sandy soil, Uplistsikhe, Gori Municipality, 600 m a.s.l., N41.9593 E44.2414,

05.06.2019, A. Jorjadze, TBI5022794; on calcareous soil, Taribana, Chachuna Sanctuary, Dedoplistskaro Municipality, 460 m a.s.l., N41.3187 E 45.9896, 05.11.2019, A. Jorjadze, TBI5022801; on sandy soil, steppe community, near David Gareji Monastery, Sagarejo Municipality, 600 m a.s.l., N45.3766 E41.4532, 11.11.2019, A. Jorjadze, TBI5022807.

Geographic distribution: Algeria, Armenia, Azerbaijan, Egypt, France, Hungary, India, Iran, Israel, Jordania, Kazakhstan, Kyrgyzstan, Mali, Maure-

tania, Morocco, Russia, Somalia, Soudan, Spain, Tunisia, Turkmenistan, Ukraine, Yemen; North Africa, Eastern Africa, North America [9, 23, 30, 33, 34].

Gastrosporiaceae Pilát

***Gastrosporium simplex* Mattir., Mém. R. Acad. Sci. Torino, Ser. 2 53: 361 (1903) (Fig. 1h)**

Fruitbody hypogeous, chalky white, spherical or ellipsoid, pearl-like, 0.8-1.4 cm diam., with white



a



b



c



d



e



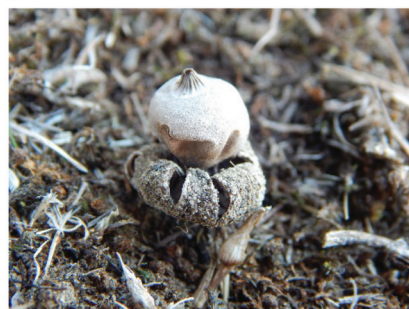
f



g



h



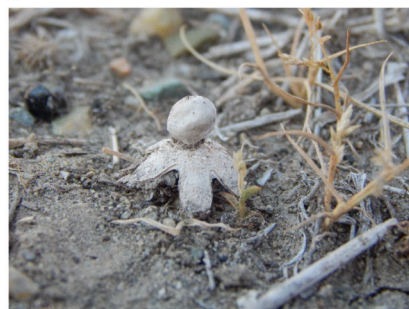
i



j



k



l

Fig. 1 a – *Disciseda bovista*, b – *D. candida*, c – *Chlorophyllum agaricoides*, d – *Mycenastrum corium*, e – *Tulostoma brumale*, f – *T. fimbriatum*, g – *T. volvulatum*, h – *Gastrosporium simplex*, i – *Geastrum campestre*, j – *G. coronatum*, k – *G. floriforme*, l – *G. minimum*

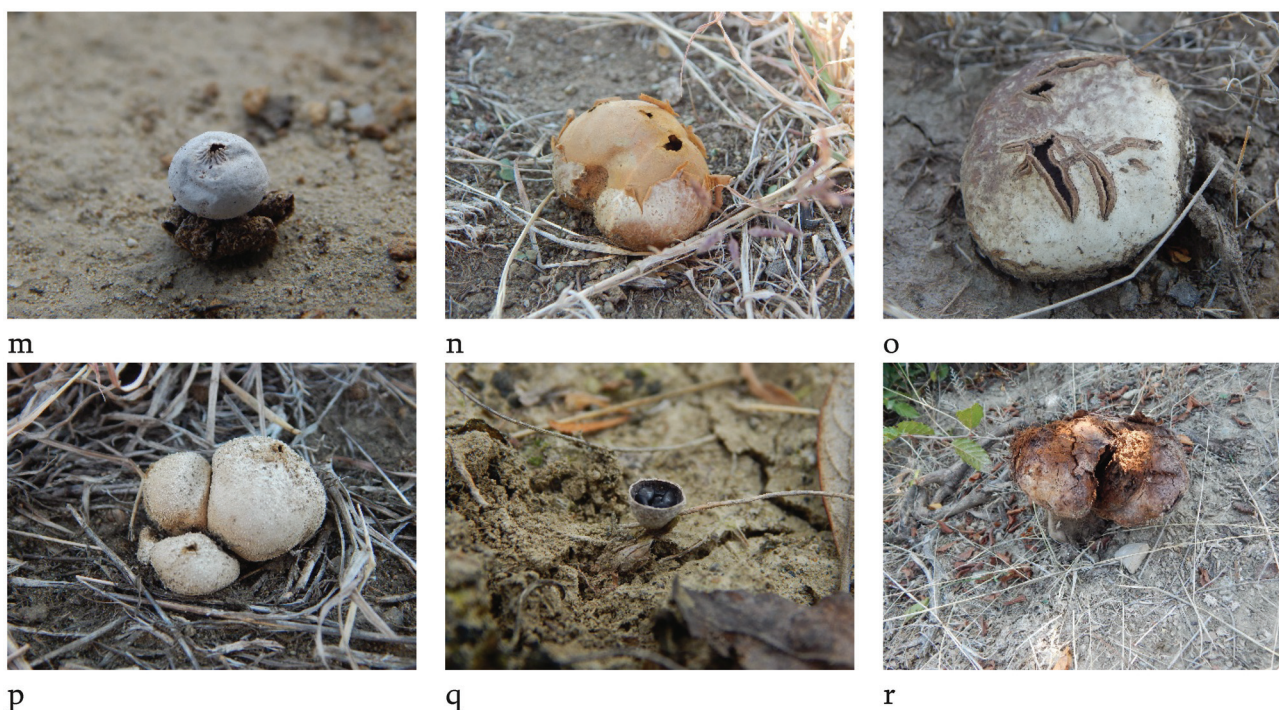


Fig. 1 (cont.) m – *Geastrum xerophilum*, n – *Calvatia candida*, o – *C. cyathiformis*, p – *Lycoperdon perlatum*, q – *Cyathus stercoreus*, r – *Pisolithus arhizus*

mycelial cord 5-12 cm long and 1 mm thick, subgleba absent, growth solitary or in small groups. Exoperidium chalky white, flocculent, covered by with calcium oxalate crystals. Endoperidium at first pale ochreous and cartilaginous, then grey and membranous, cracking at maturity. Gleba whitish grey and soft, then pale ochraceous and powdery, without capillitium. Spores spherical or ellipsoid $3.6-5.2 \times 4-5 \mu\text{m}$, pale ochraceous, finely verrucose.

Habitat: Underground carpophore found among roots of various herbaceous plant species. Ground surface covered with mosses (*Pleurochaete squarrosa* (Brid.) Lindb.) and lichens (*Cladonia rangiformis* Hoffm.). Near *Paliurus spina-christi* shrub.

Material examined: Steppe community, near David Gareji Monastery, Tapobi, Sagarejo Municipality, 600 m a.s.l., N45.3766 E41.4532, 11.11.2019, A. Jorjadze, TBI5022805.

Geographical distribution: Argentina, Austria, Bulgaria, Czech Republic, France, Germany, Great Britain, Italy, Kazakhstan, Pakistan, Poland, Slovakia, Spain, Sweden, Switzerland, Ukraine [9, 23, 33, 35, 36].

Notes: *G. simplex* grows in well ventilated and sunny places, where ground surface temperature reaches 45°C. On calcicolous soils. Associated with various grasses: *Stipa* L., *Festuca* L., *Bromus* L., *Sesleria* Scop., *Agropyron* Gaertn., *Artemisia* L., *Carex* L. and others [23, 36-38].

Geastraceae Corda

***Geastrum campestre* Morgan, Am. Nat. 21: 1027 (1887) (Fig. 1i)**

Material examined: On sandy soil, under *Rhamnus pallasii*, Uplistsikhe, near old cemetery, Gori Municipality, 615 m a.s.l., N41.97182 E44.20432, 25.09.2019, A. Jorjadze, TBI5022784; steppe community made up of *Bothriochloa ischaemum*, Gareji dryland, Sagarejo Municipality, 600 m a.s.l., N45.3766 E41.4532, 11.11.2019, A. Jorjadze, TBI5022825.

Geographic distribution: Armenia, Australia, Austria, Czech Republic, Denmark, France, Germany, Great Britain, Hungary, Japan, Kazakhstan, Lithuania, Norway, Romania, Russia, Slovakia, Spain, Sweden, The Netherlands, Ukraine; South Africa, North America [9, 23, 30, 32, 33, 39].

***Geastrum coronatum* Pers., Syn. meth. fung. (Göttingen) 1: 132 (1801) (Fig. 1j)**

Material examined: Among mosses, under *Rhamnus pallasii*, Uplistsikhe, near old cemetery, Gori Municipality, 615 m a.s.l., N41.9718 E44.2043, 25.09.2019, A. Jorjadze, TBI5022818.

Geographic distribution: Armenia, Austria, Bulgaria, Czech Republic, Denmark, Estonia, France, Germany, Great Britain, Greece, Hungary, Kazakhstan, Kyrgyzstan, Lithuania, New Zealand, Norway, Poland, Portugal, Romania, Slovakia, Spain, Swe-

den, The Netherlands, Ukraine; North America, Central America, Australia, Africa [9, 23, 30, 32, 33, 39].

***Geastrum floriforme* Vittad., Monogr. Lycoperd. (Torino): 167 (23 of prepr.) (1842) (Fig. 1k)**

Fruitbody at first spherical 1-1.5 cm wide, slightly concave at base, greyish, at maturity exoperidium splits into 6-9 unequal rays, expanded fruiting body 2-4 cm diam., lobes strongly hygroscopic, upper surface of rays glabrous and brown, in dry conditions the rays curl around the fruitbody covering it. Endoperidium sessile, globose to depressed globose, 0.5-1.5 cm diam., grey-brown; peristome indeterminate, with uneven fibrillose edge. Gleba dark brown, powdered. Spores globose, brownish, warted, 5.5-6 µm.

Habitat: On sandy soil, with dry mosses.

Material examined: Uplistsikhe, near old cemetery, Gori Municipality, 615 m a.s.l., N41.9718 E44.2043, 25.09.2019, A. Jorjadze, TBI5022813.

Geographical distribution: Argentina, Armenia, Australia, Austria, China, Czech Republic, Denmark, Finland, England, France, Germany, Great Britain, Italy, Kazakhstan, Mexico, New Zealand, Poland, Portugal, Romania, Russia, Slovakia, Spain, Sweden, The Netherlands, Ukraine, United States; Southern Africa [9, 23, 30, 33, 40, 41].

Notes: *G. floriforme* morphologically similar to *G. corollinum*. However, *G. floriforme* basidiocarps are hypogeous when unexpanded, have indistinctly delimited peristomes and mycelial layer is encrusted with sand or plant debris. *G. floriforme* differs from *G. hungaricum* by its indistinctly delimited peristome, smooth endoperidial surfaces, and larger basidiospores. *G. kotlabae* can be segregated due to its plicate peristome and verrucose endoperidium [41-43].

***Geastrum minimum* Schwein., Schr. naturf. Ges. Leipzig 1: 58 [32 of repr.] (1822) (Fig. 1l)**

Material examined: On soil, steppe community, near artificial lake, near David Gareji Monastery, Sagarejo Municipality, 620 m a.s.l., 41.4570, 45.3710, 14.10.2019, A. Jorjadze, TBI5022815; on soil, steppe community, Gareji dryland, Sagarejo Municipality, 770 m a.s.l., N41.4874 E45.3277, 07.11.2019, A. Jorjadze, TBI5022804.

Geographic distribution: Australia, Austria, Belgium, Congo, Czech Republic, Denmark, Estonia, Finland, France, Germany, Great Britain, India, Iran, Israel, Italy, Japan, Kazakhstan, Latvia, Lithuania, New Zealand, Nigeria, Norway, Pakistan, Portugal, Romania, Slovakia, South African Rep., Spain, Sweden, Switzerland, The Netherlands, Ukraine;

North America, Central America, South America [9, 23, 32, 33, 41].

***Geastrum nanum* Pers., J. Bot. (Desvaux) 2: 27 (1809)**

Material examined: On sandy soil, open area, Uplistsikhe, near old cemetery, Gori Municipality, 615 m a.s.l., N41.9718 E44.2043, 25.09.2019, A. Jorjadze, TBI5022783.

Geographic distribution: Australia, Austria, Belgium, Great Britain, Czech Republic, Denmark, Estonia, Finland, France, Germany, India, Ireland, Italy, Kazakhstan, Kenya, Latvia, Lithuania, Norway, Poland, Romania, Russia, Slovakia, South African Rep. Spain, Sweden, Tanzania, The Netherlands, Ukraine; Southern Africa, Eastern Africa, North America, Central America, South America (9, 23, 32, 33, 34, 40).

***Geastrum xerophilum* Long ex Desjardin, Pacific Sci. 65(4): 493 (2011) (Fig. 1m)**

Fruitbody at first spherical, at maturity exoperidium splits into 6-7 non-hygroscopic rays rolling up under endoperidium. Fully expanded fruitbody 15-20 mm diam. and 7-10 mm tall. Rays greyish brown, surface encrusted with sand. Endoperidium globose, 10 mm diam., stalked, pallid-grey, surface furfuraeous, then glabrous. Peristome conical, 1 mm tall, not delimited, sulcate. Gleba brown. Spores globose, warted, 5-6 µm diameter.

Habitat: On sandy soil.

Material examined: Open area, Uplistsikhe, near old cemetery, Gori Municipality, 615 m a.s.l., N41.9718 E44.2043, 06.10.2020, A. Jorjadze, TBI50225240.

Geographic distribution: Brazil, Hawaii, Mexico, Spain, United States [41].

Notes: *Geastrum xerophilum*, a species typical of xerophytic environments, occurs in semi-arid climate with low irregular rainfall and high temperature and evapotranspiration. The species is morphologically similar to *G. campestre* Morgan, which differs in its hygroscopic rays, delimited peristome, and larger spores (6.5-8.0 µm diam.) [44].

Lycoperdaceae Chevall

***Calvatia candida* (Rostk.) Hollós, Term. Füz. 25: 112 (1902) (Fig. 1n)**

Material examined: On sandy soil, steppe community, Gareji dryland, Sagarejo Municipality, 800 m a.s.l., N45.3182 E41.4747, 14.10.2019, A. Jorjadze, TBI5022795; on sandy soil, steppe commu-

nity, Gareji dryland, Sagarejo Municipality, 600 m a.s.l., N45.3766 E41.4532, 11.11.2019, A. Jorjadze, TBI5022791.

Geographic distribution: Armenia, Australia, Czech Republic, Germany, Hungary, India, Iran, Italy, Kazakhstan, Kyrgyzstan, Lithuania, Poland, Portugal, Romania, Russia, Slovakia, South African Rep., Sweden, The Netherlands, Ukraine; North America, South America [9, 23, 30, 32, 33, 45].

***Calvatia cyathiformis* (Bosc) Morgan, J. Cincinnati Soc. Nat. Hist. 12(4): 168 (1890) (Fig. 1o)**

Material examined: On sandy soil, steppe community, Gareji dryland, Sagarejo Municipality, 800 m a.s.l., N45.3182 E41.4747, 14.10.2019, A. Jorjadze, TBI5022822.

Geographic distribution: Africa, Armenia, China, Cuba, Japan, India, Lithuania, Ukraine, United States; East Africa, South America [26, 30, 32-34, 45, 46].

***Lycoperdon perlatum* Pers., Observ. mycol. (Lipsiae) 1: 4 (1796) (Fig. 1p)**

Material examined: On soil, steppe community, near artificial lake, near David Gareji Monastery, Sagarejo Municipality, 620 m a.s.l., 41.4570, 45.3710, 07.10.2019, A. Jorjadze, TBI5022782.

Geographic distribution: Armenia, Australia, Austria, Azerbaidjan, Belgium, British, Bulgaria, China, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, India, Iran, Ireland, Italy, Kazakhstan, Kyrgyzstan, Lithuania, Luxembourg, New Zealand, Norway, Poland, Portugal, Romania, Russia, Slovenia, South African Rep., Spain, Sweden, Switzerland, The Netherlands, Ukraine, United States, Yugoslavia; South America, Tasmania [9, 23, 26, 30, 32, 33].

Nidulariaceae Dumort

***Cyathus stercoreus* (Schwein.) De Toni, in Berlese, De Toni & Fischer, Syll. fung. (Abellini) 7(1): 40 (1888) (Fig. 1q)**

Fruitbody narrowly bell-shaped, 7 mm tall, 4 mm diam., narrows downward to 1 mm diam., on the outside hairy, gray to brownish white, internally surface smooth, lead black. Peridioles lead black, smooth, lenticular, 2 mm diam., peridioles attached to peridium with white epiphragm. Spores globose to subglobose, 22-30 µm diam., smooth, thick-walled 4 µm thick.

Habitat: On manured and sandy soil, straw.

Material examined: Kotsakhuri dry gorge, southern macro-slope of the Kvernakebi Range, Kaspi Municipality, 600 m a.s.l., N41.9602 E44.3801, 01.12.2019, A. Jorjadze, TBI5022803.

Geographic distribution: Africa, Armenia, Australia, Austria, British, China, Corse, Cuba, Czech Republic, Denmark, France, Germany, Greece, India, Iran, Israel, Italy, Kazakhstan, Lithuania, New Zealand, Norway, Portugal, Romania, Russia, Slovakia, South African Rep., Spain, Sweden, Switzerland, The Netherlands, Ukraine, Zimbabwe; North America, South America [9, 23, 30, 32, 33].

Sclerodermataceae Corda

***Pisolithus arhizus* (Scop.) Rauschert, Z. Pilzk. 25(2): 50 (1959) (Fig. 1r)**

Material examined: On eroded soil, meadow, area of about 5 m radius around *Rhamnus pallasii*, *Paliurus spina-christi*, *Carpinus orientalis* Mill. scrub, Kotsakhuri dry gorge, southern macro-slope of the Kvernakebi Range, Kaspi Municipality, 600 m a.s.l., N41.9602 E44.3801, 14.09.2019, A. Jorjadze, TBI5022781; on soil, under *Carpinus orientalis*, Kotsakhuri dry gorge, southern macro-slope of the Kvernakebi Range, Kaspi Municipality, 600 m a.s.l., N41.9602 E44.3801, 10.10.2019, A. Jorjadze, TBI5022789.

Geographic distribution: Austria, Belgium, British, Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Israel, Italy, Mauritius, Norway, Pakistan, Poland, Portugal, Russia, Thailand; South African Rep., Spain, Sweden, The Netherlands, Ukraine, Zambia [9, 33, 47, 48].

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Health promotional apple as an ideal substrate for probiotic beverages

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ABSTRACT

Most probiotic foods are based on dairy products. However, some people, including children, are characterized by intolerance to milk sugar- lactose. Probiotic-rich fruit juices are a good alternative to dairy products as they are free of lactose and cholesterol. Among the probiotic microorganisms, the genus of *Lactobacillus* is most often used in the production of food products. Functional food obtained in this way is also available to vegetarian consumers. The development of non-dairy probiotic products has been widely studied. The focus is made using fruits, vegetables, and grains as raw materials. This paper explores the benefits of fortification of fruit juices with probiotics using autochthonous microorganisms that not only alter the taste of drinks but also preserve the nutritional content of the fruit. It also describes the factors that affect the viability of strains of probiotic microorganisms in juices during production.

Keywords: Health, Functional foods, Apple, *Lactobacillus*, Probiotic fruit beverages, Raw materials.

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Introduction

The increase in demand for probiotic products and the urgency of problems related to lactose intolerance have led to the development of non-dairy probiotic beverages [1]. By the data suggested in 2019, about 65-70% of the world population is expected to be lactose intolerant [2]. Hippocrates first described lactose intolerance 2400 years ago, but clinical symptoms have only been recognized for the last 50 years [3]. Lactose intolerance is a deficiency of the genetically determined enzyme beta-galactosidase (lactase), which makes impossible to break down lactose into monosaccharides – glucose and galactose [4]. Symptoms such as abdominal discomfort, bloating or gas, spasm, and diarrhea are common in lactose intolerant people [5]. One way to solve this problem is to take probiotics the effectiveness of which depends on the number of lactic acid bacteria and lactose in the product. Lactose intolerance is prevalent in Europe. The percent-

age has been rising quickly to 17% in Finland and northern France. It is over 50% in South America, Africa, and Asia, and in some Asian countries, it reaches almost 100% [6]. It is clear, that lactose intolerance is very spread over the world and creation of substitute food for such consumers is important. As a result, there is increasing market need for probiotic non-dairy products. In addition, with the growth of vegetarian consumers, there is a high demand for plant-based probiotic products.

Comparing to other probiotic microorganisms, the genus of *Lactobacillus* is the most frequently used in the production of food. The development of non-dairy probiotic products has been extensively studied, including the emphasis on the use of raw fruits, vegetables, and cereals [7]. According to the Food and Agriculture Organization of the United Nations (FAO) and World Health Organization (WHO), probiotics are defined as “living microorganisms that, when present in adequate amounts, have a positive effect on the health of the host or-

ganism” [8]. The recommended concentration of probiotics is at least 10⁸ to 10⁹ colony-forming units per milliliter (CFU/ml) to maintain a minimum intestinal concentration of 10⁶ to 10⁷CFU / ml [9-11].

There are important criteria that must be met by selected probiotic strains: Non-pathogenic and non-toxic [12]; representative of the normal human microflora [13]; ability to survive in the human gastrointestinal tract, namely resistance to salivary enzymes, gastric acid pH, pancreatic juice and bile salts [13,12], adhesion, colonization and making stable population to the intestinal epithelium [4,13]; Durable enough to withstand commercial production, processing, and distribution [14]; Production of antimicrobial compounds, bacteriocins against pathogens [15]; To have a beneficial effect on the host organism [16]; It should also have good sensory characteristics to avoid unpleasant flavor and texture [17,18].

In addition, probiotics should be able to hydrolyze substances in fruits and vegetables that cannot be processed by the host, such as fructans and galactans, fructooligosaccharides (FOS), mannanoligosaccharides (MOS), xylooligosaccharides (XOS), inulin and some antinutritional factors as tannins [19,20]. They must produce useful components such as vitamins, antioxidants and antimicrobial substances such as organic acids (lactic acid and acetic acid), hydrogen peroxide, bacteriocins, aldehydes, acetoin, carbon dioxide, reuterin, reutericyclin, phenolic acids, peptides, and short chain fatty acids [21].

For example, a study by Petrov, Popova, and Petrova found that *Lactobacillus paracasei* DSM 23505 had the ability to produce large amounts of lactic acid by simultaneous saccharification and fermentation of inulin (SSF) [22]. The probiotic properties of *Lactobacillus Plantarum* MTCC 1325, a strain of *Lactobacillus*, have also been found to be associated with the reduction of Alzheimer's disease by the production of acetylcholine [23]. Because acetylcholine is a neurotransmitter that transmits nerve signals, its decreased levels have strong connections with the progression of Alzheimer's disease [24].

Probiotic fruit beverages as functional foods: benefits over dairy probiotics

Functional food refers to food whose nutritional level is improved in various ways. One of them is to

add probiotics [8]. For this purpose, different substrates such as cheese, powdered milk, ice cream, dairy desserts, butter, mayonnaise, and fermented vegetable foods are used [25]. However, the presence of allergens, lactose intolerance, fat content, and cold storage requirements are limitations of probiotic dairy products [26, 27]. This aspect has led to the creation of new probiotic products based on non-dairy substrates. Various raw materials [28] such as fruits, vegetables, wheat, and legumes have been studied for this purpose. Fruits and vegetables are considered to be one of the best sources as they contain minerals, fiber, vitamins and antioxidants [29]. They are also allergy free and easily available [30]. They are characterized by low cholesterol and have a vegan-friendly status [31].

According to literary data, the functional food market is one of the main attractive areas for research and innovation in the food sector. Probiotics are included in a variety of foods, such as dietary supplements, functional foods, and animal feed, as well as therapeutic and prophylactic health programs. Based on a recent market research report the market for probiotics is evaluated at USD 49.4 billion in 2018, and will reach USD 69.3 billion by 2023 [32]. Developing probiotic juices using plant substrates without interfering with the sensory side is an innovative idea for the development of functional juices. These juices are enriched with active components such as probiotics, prebiotics, phenols, flavonoids, and antioxidants [30] that are naturally present in fruits and vegetables and attract people of all ages [33]. The microbial composition of fermented juice improves gastrointestinal health and is responsible for maintaining the achieved results [34]. Given the above facts, fruits and vegetables can be used as a potential substrate for probiotic drinks [35].

The benefits of fortified fruit juices with probiotics are: [36]

- Rich in nutrients (vitamins, antioxidants, and polyphenols);
- Taste properties that attract attention for people of all ages;
- Consumed regularly, which is needful for the beneficial effects associated with probiotics;
- Considered a healthy product by the population, mainly due to its fortification with vitamins or calcium;
- Free from starter cultures that compete with probiotics in food source;

- Generally, contain antioxidant ingredients, such as ascorbic acid, to help create anaerobic conditions;
- Contain significant amounts of sugars that can be converted by the beneficial cultures;
- Do not contain allergens such as lactose and casein, which interfere with the consumption of dairy products by some population;
- Naturally free from cholesterol;
- Their movement through the gastrointestinal tract is relatively rapid, which reduces the exposure to probiotics in the host environment, such as gastric acidity.

Preparation of probiotic fruit beverages and approaches for improvement of their probiotic properties

In recent years, lactic acid bacteria have been added to fruit or vegetable juices to make probiotic drinks. Lactic acid fermentation not only changes the flavor of beverages but also preserves the nutritional composition of fruits and vegetables [37].

However, it is important to create an appropriate environment for probiotic strains in the juice to have a positive effect on human health. Many reviews on probiotics emphasize that they cannot be maintained after processing, storage, and digestion [10], which naturally affects both the quality of the product and the economic side of the manufacturer. There are several stages that can affect the viability of probiotic bacteria. In addition to being sensitive to technological processes, they must withstand the acidic environment of the stomach and the bile salts of the small intestine before reaching their destination [38]. They must also be resistant to enzymes, such as lysozyme present in the intestine, as well as to toxic compounds including phenols. They arise during digestion. Antibiotics, bacteriophages, and anaerobic conditions also affect the viability of probiotics [39]. Among the processing parameters that affect the activity of bacterial strains are pH, titratable acidity, water activity, incubation temperature, sugar content and chemicals such as hydrogen peroxide, molecular oxygen, bacteriocins, artificial flavoring, coloring agents, heat treatment, rate and proportion of inoculation, strain species, packaging materials and conditions, storage methods [40].

Numerous attempts have been made in various food products to improve their growth and viability during their production and storage [41]. Strategies include not only the strains having the desired prop-

erties selected in accordance with the above parameters but also the microencapsulation and synthesis of micronutrients such as peptides and amino acids [42].

Among the various probiotics, it is generally found that lactobacilli have the ability to resist and survive in fruit juices, with a pH of 4.3 to 3.7, while bifidobacteria are less acid-tolerant; even a pH of about 4.6 is unfavorable for their survival [43]. According to Ranadheera et al. the integration of LAB in fruit juices at low pH may increase the resistance of bacteria to stressful acid conditions [44]. Problems with adding probiotic cultures to some fruit juices can be solved by mixing with small amounts of other juices. For example, when *Lactobacillus* strains are added to fruit juices that contain citric acid in orange juice and malic acid in apple juice, bacteria convert these acids to produce CO₂, acetic acid, and lactic acid. Addition of 5% cherry juice to orange juice helps to prevent flatulence after 3 weeks and does not significantly affect cell counts of *L. plantarum* HEAL9 and *L. paracasei* 8700:2 at 8 ° C for 4 weeks [45].

As for commercial production, probiotic culture is added to the fruit juices after heat treatment because the microorganism is sensitive to high temperatures. Usually, the probiotic culture is added to the juice in an activated form, after the sequential multiplication of the lyophilized culture in the (MRS) broth. Costa et al. also suggested the use of orange juice as a substitute for MRS broth, and studies have shown that orange juice is a suitable substrate for the propagation of *Lactobacillus paracasei* [46]. It should also be noted that the addition of probiotics to juices may require special technology, as the microorganism may not be able to withstand a number of processing processes (e.g., pasteurization temperature) and raw material conditions (e.g., acidity). Hansen established a flexible formulation system in 2005 according to which probiotics are added directly to the finished liquid product. The technology uses an aseptic dosing apparatus that allows bacteria to be added only before packaging [47].

Apple as an ideal substrate for probiotic fruit beverages

Among fermented fruit juices, the production of apple juice is wide spread. Properties for apples as raw materials, different techniques of production of apple juices, and environmental conditions give the research specificity [48]. Ninety percent of fer-

mented food is produced from natural, autochthonous microflora [49]. The surface of the apple is a natural reservoir of both yeasts and bacteria [50]. In 2013, Shade, McManus and Handelsman studied the microbiome of apple flower. They described the existence of different bacterial backgrounds that develop differently from bud to fruit [51]. This study highlighted that the apple flowers are carriers of bacteria that can be used in the juice making process (mainly successfully are used Lactobacillaceae and Acetobacteraceae families) [48].

Cultivation methods play an important role in the formation of microbial composition, both in terms of abundance and diversity. The condition of organically and pesticide-poisoned apples differs radically in terms of microorganisms [52, 53]. The organic apple phyllosphere is distinguished with more abundance [54]. The microflora of the raw material is also strongly influenced by the sampling techniques, the sorting quality, and the storage conditions. The advantage of collecting apples from the ground was determined from the point of bacterial diversity [48].

Thanks to their taste and aroma, apples allow the production of probiotic juice. For this purpose, Pereira et al. [55] used Cashew apples as a substrate,

and the juice was fortified with *L. casei*. Oligosaccharides are formed during the fermentation of cashew apple juice. This fruit showed good growth for *L. casei* compared to dairy products. The fermented probiotic drink of cashew apple can be stored for 42 days in refrigerated conditions [55], which underlines its potential for commercialization.

Current market of probiotic fruit juices

There are already several new non-dairy probiotic drinks on the market. Proviva was the first probiotic product, which does not contain milk or milk components. It was launched in Sweden by Skane Dairy in 1994. The product is lactic acid-fermented oatmeal that was mixed with fruit juice. Melted grain culture was added to increase the liquid mass of the product, and *Lactobacillus plantarum* to carry out fermentation. This formula is used as the active ingredient in a food product in which 5% of oatmeal is mixed with a fruit drink with final content of *L. plantarum* 5×10^{10} CFU/L [56]. Table 1 gives some examples of non-probiotic products presented in the international market. Table gives some mixed with a fruit drink with final content of of *L. plantarum* 5×10^{10} CFU/L.

Table. Some probiotic fruit drinks, which are commercially available [38]

Probiotic Product	Probiotic Microorganisms	Company
Biola	<i>Lactobacillus rhamnosus</i> GG	Tine BA, Norway
Bioprofit	<i>Lactobacillus rhamnosus</i> GG, <i>Propionibacterium freudenreichii</i> , Shermanii JS	Valio Ltd., Finland
Bravo Friscus	<i>Lactobacillus plantarum</i> HEAL9, <i>Lactobacillus paracasei</i> 8700:2	Skanemajerier, Sweden
Gefilus	<i>Lactobacillus rhamnosus</i> GG	Valio Ltd., Finland
GoodBelly drink	<i>Lactobacillus plantarum</i> 299v	Next Foods, Colorado
Healthy life probiotics	<i>Lactobacillus paracasei</i> 8700:2, <i>Lactobacillus plantarum</i> Hea19	Golden circle, Australia
Rela	<i>Lactobacillus reuteri</i> MM53	Biogaia, Sweden

Despite the variety and popularity of Georgian juices, there are no probiotic juices on the current market in Georgia. The production of this type of juice on our market appears to be beneficial both from an economic point of view and that of public health. Besides, apple from fruit crops account

for 50% of the fruit produced by the local market in Georgia [57]. Regard to this fact, of particular interest could be apples as a substrates producing probiotic fruit beverage.

Economic and social context of Georgia, the Georgian agrifood economy and consumption pat-

terns. Georgia is still a country in transition, still under the influence of its past, i.e. the past associated with the Soviet Union. Growing domestic and external demands contributed to the economic growth, which has led the country to increase consumption, exports, and tourism. Gross Domestic Product (GDP) remained stable (5.1%) in 2019 thanks to several factors: good investment, increased government spending, good structural reforms, and the country's growing integration into regional and global economies. According to the updated forecast of the International Monetary Fund, from 14th April 2020, due to COVID19, GDP growth is expected to fall to 4% in 2020 and reach 3% in 2021, depending on the post-pandemic global economy situation [58].

According to the latest data of the International Monetary Fund, the unemployment rate in Georgia in 2019 was 11.6%. Poverty has almost halved in recent years, thanks to social policies and economic growth, but it has remained at the same level due to employment problems (16.3% in 2017, according to the World Bank data). Inequality remains high compared to other economies in the region, although a downward trend is still observed in this direction [58].

There are more than 2.7 million employed people out of 3.7 million in Georgia (according to the World Bank). The country has an agricultural tradition that has contributed to the development of the country's economy over the years. However, the agricultural sector has decreased since 1995. Today, 6.7% of GDP belongs to agriculture (World Bank). Ninety-eight percent of farmers are self-employed and production is mostly for self-consumption. More than 40% of the territory of Georgia is considered to be agricultural land, which also includes pastures and grasslands. The main agricultural products are cereals, early and late vegetables, technical or industrial crops, subtropical plants, fruit varieties, melons and pumpkins, tobacco, and grapes, rice, and tea. Stock raising is also developed and the population has livestock. Georgia is also one of the oldest regions in terms of wine production and is rich in its drinking water resources. Georgia has signed the Deep and Comprehensive Free Trade Agreement (CFTA) with the European Union, which stipulates that all Georgian agricultural products can be exported to the EU market without any commitments [58].

Since the industrial sector shrank both during the collapse of the Soviet Union and from 2004 to

2008, there has been a moderate growth trend in recent years. Thanks to it, the GDP is now 19.9%, and the number of employed people is 13.2% (World Bank). The industrial sector mainly includes food processing and the production of chemicals and textiles [58].

Currently, the goal of the Government of Georgia is to take care of the development of the country's agricultural infrastructure in terms of processing and storage of agricultural products, which will help increase the productivity and competitiveness of Georgia's agriculture. Achieving this can be possible by attracting investment in this area, and these efforts will be expected to meet local demand and increase the country's export potential [59].

An important link in achieving this goal is the various organizations, in particular the Agricultural Efficiency Recovery Project (USAID / REAP), funded by the United States Agency for International Development (USAID). It contributes to rural income growth and job creation by attracting investment in agribusiness and providing technical assistance [60]. Within the framework of the "Enterprise Georgia" project, the Georgian Beer Company introduced the production of Georgian natural fruit juices using a new, aseptic method [61]. However, there appears to be scope for more innovative food product developments and probiotic beverages could be one of them.

Conclusion

Creating a functional food using lactic acid bacteria and fruit substrates as prebiotics makes it possible for a wide range of people to get the desired benefits. Technologies are developed based on scientific research that help to avoid as much as possible the reduction of the activity of probiotic strains during food processing, which affects the quality of the final product and the economic prospects for entrepreneurs as well. The problems described in the article and the ways to solve them underline the view that these types of products have a promising future and could contribute to the development of the agrifood and economy sector of countries such as Georgia.

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The integrated technology of functional products of grapes

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ABSTRACT

The study aimed to obtain grape jam and compote according to modern requirements, based on the method of osmotic dehydration and the use of deionized grape concentrate as a sugar substitute.

Nutritional and functional properties are important for the estimation of the grape cultivar. From this point of view, Alphonse Lavallée has been chosen, which is dark-skinned and is used mainly as a table cultivar; it is obtained in France by the cross-breeding of Hamburg muscat and the Georgian cultivar Colchian kharistvala.

The deionized concentrate of grape with SS content 70 B is used as an osmotic agent; the duration of the process is 5 hours: the initial temperature is 40 °C, duration 1 h, at the next stage - 30 °C; the mass ratio of the osmotic agent and grapes is 1:1.

The results of osmotic dehydration of grape are: weight reduction WR= 26.0%, solid gain 4.1%; water loss WL=30.1%, the amount of soluble solid substance that went into osmotic solution is 1.8%.

To produce a jam, the deionized concentrate of grapes has been added to dehydrated fruit, mass ratio 60:40.

In the case of compote, the syrup is added to the dehydrated fruit, which is obtained by diluting the osmotic agent with water, a concentration is 5.0... 7.0%, mass ratio 60:40.

As a result, the product contains more fruit, less free sugar, the energy value is reduced, anthocyanins are preserved better.

Keywords: Grape, Osmotic dehydration, Jam, Compote, Anthocyanins, Free sugar.

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Introduction

According to the available information, the grape has the potential to maintain human health - it suppresses the development of chronic diseases; it is distinguished by a unique combination of phenolic compounds; therefore, it is characterized by strong antioxidant activity and antimicrobial properties. It is believed that grapes and products derived from them should be included in the daily ration. The main thing is to use this opportunity properly [1-4].

The interest in respect of anthocyanins has significantly increased in recent decades. They may play an important role in the preservation of health with the point of view of prophylaxis - obesity, cardiovascular diseases, inflammatory processes.

The anticarcinogenic action should be specially noted [4]. Due to the content of anthocyanins grapes are considered one of the most important cultures in the world [3, 5].

The results of the research confirm that it is expedient to use the whole fruit - skin, flesh, pip. In such case, except for antioxidants, contents of fibrous substances is also important, which promote normal functioning of the digestive system [1,6]. The mentioned is enforced by the fact that high attention is paid to the consumption of table grape [7-9].

The beneficial properties of the processed products are determined not only by the object but also by the technology of processing. In particular, the use of free sugar; this factor should be taken into

consideration.

World Health Organization recommends a significant limitation of free sugar that should be <10% of total energy consumption (2000 kcal). It is to be mentioned that this does not extend to sugars being in fruit and vegetables [10,11]. The recommendations of the World Health Organization and the requirements of the European Union are to be taken into consideration. Technology is important - more content of fruit and reduced quantity of sugar already means high quality [12, 13].

The deionized concentrate of grapes may be used as a natural sweetener [14, 15]. It is to be mentioned that grape concentrate contains almost equal quantities of glucose and fructose.

Grape juice is considered as a prophylactic product in respect to chronic diseases, despite the high content of sugar [16, 17]. It appears to retain a function of natural sugar on the background of biologically active substances. The deionized concentrate of grape has a similar function. From this point of view, it is important to use the method of osmotic dehydration, based on which a concentration of natural sugar in fruit increases.

The project is based on trends existing in Europe. Since 2012 a production of jam, compote, confiture, etc., has been significantly increased. The essence of technology is more fruit, less sugar [17].

Now an old recipe of jam regarding sugar has been changed. Food producers on the international level take into consideration the conclusions of the World Health Organization and the demands of consumers. Therefore, a preference is shown to a reduction of sugar content: instead of 65%, a concentration is 40-55% [13, 18].

The importance of compote is multifaceted, and its technology makes it possible to produce modern processed products that take into account the following changes: reduction of energy value, increasing of relative content of the fruit, use of sugar substitutes.

Osmotic dehydration is the process by which water is partially removed from plant tissue. For this purpose, the fruit is placed in a hypertonic (osmotic) solution and is in direct contact with it. There are three types of mass exchange: a motion of water from tissue to an osmotic solution, a going of an osmotic substance from solution to tissue, the diffusion of own dry substance from tissue to solution [19-23].

This is an important means of reducing fruit mass, based on which this method has gained great

interest and is widely used as an effective method of pre-processing, mainly in drying and freezing technology. It should be noted that the osmotic agent, its concentration, processing time, and temperature are different in each specific case.

The study aimed to obtain grape jam and compote according to modern requirements, based on the method of osmotic dehydration and the use of deionized grape concentrate as a sugar substitute.

Objects and methods

Nutritional and functional properties are important for the estimation of the cultivar. From this point of view Alphonse Lavallée, which is a dark-skinned grape and is used mainly as a table cultivar has been chosen; it is obtained in France by the cross-breeding of Hamburg muscat and the Georgian cultivar Colchian kharistvala.

The research comprises two stages. Firstly the parameters of osmotic dehydration have been determined, the obtained material became the basis of estimation of jam and compote from the nutritional and functional points of view.

Grapes harvested at the optimal stage of ripeness were subjected to the experiment. It was washed, inspected, and placed in an enameled container in

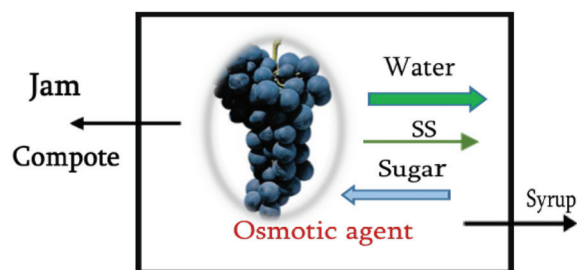


Fig.1. Osmotic dehydration of rapes

the amount of 500 g, the procedure was repeated five times.

The deionized concentrate of grape with SS content 70 °B is used as an osmotic agent; the duration of the process is 5 hours, initial temperature 40 °C, duration 1 h, at the next stage – 30 °C; the mass ratio of the osmotic agent and grapes is 1:1.

The kinetics of the process of osmotic dehydration has been evaluated according to the following parameters:

$$\text{weight reduction } \text{WR}(\%) = \frac{M_0 - M}{M_0} 100$$

$$\text{dry substance gain } \text{SG} \% = \frac{MS - M_0 S_0}{M_0} 100$$

$$\text{water loss } \text{WL}(\%) = \text{WR} + \text{SG}$$

M_0 – the initial mass of the sample, g;

M – the mass of the sample after dehydration, g;

S_0 – the initial quantity of a solid in the sample, g;

S – the content of a solid in the sample after dehydration, g Osmotic dehydration data:

$$WR(\%) = \frac{500-370}{500} 100 = 26.0$$

$$SG(\%) = \frac{370 \cdot 22.5 - 500 \cdot 16.609}{500} 100 = 4.1$$

$$WL(\%) = 26.0 + 4.1 = 30.1$$

To obtain jam, a deionized concentrate of grape is added to the dehydrated fruit (SS 70 °B), ratio 60:40, triple boiling each time for 3 min, with 2-3 hours of delay in the middle.

In the case of compote, the syrup is added to the dehydrated fruit, which is obtained by diluting the osmotic agent with water. The mass ratio 60:40, the concentration of the solution 5÷7.0%, pasteurization.

To evaluate the basic data of grape, osmotic dehydration process, qualitative parameters of jam and compote, the following has been determined: soluble solids by refractometer, titratable and active acidity using pH meter, sum quantity of anthocyanins by using a spectrophotometer, the wavelength 520 nm. Degustation was conducted by 20-mark system: very good 18.1- 20; good - 15.1-18; satisfactory – 13.1-15.

Results and discussion

The grape cultivar Alphonse Lavallée deserves attention due to its sensory properties. Fruits of the same size harvested during the optimal period of ripening were subjected to the experiment. It meets the requirements for table grape varieties in terms of chemical and phytochemical data.

The information of the used object is important for the evaluation of the results. The characteristics of Alphonse Lavallée are presented in Table 1.

Table 1. Chemical and phytochemical data of grapes

SS, °B	Titratable acidity, g/100 g	pH	Monomeric anthocyanins, mg/100 g
17.0	0.51	3.7	55.2

The initial data give a basis to obtain products with positive effects as a result of osmotic dehydration.

The process of osmotic dehydration, which as a rule is aimed at removing a certain amount of water, also has other consequences: a migration of

the osmotic agent from the solution to the fruit and diffusion of small amounts of soluble solids (SS) from the raw material. The mentioned indicators determine the expediency of using grapes and osmotic solution. The results are given in Table 2.

Table 2. The results of osmotic dehydration of grapes, %

WL	WR	SG
30.1	26	4.1

Osmotic dehydration results in increasing in grapes of soluble solid substance 22.5°B, and as a result of additional transition of sugar from osmotic solution amounted to 28.1 °B (Fig. 1).

1 - SS of grapes under dehydration;

2 - SS of grapes under dehydration and transition of sugar in fruit;

An example is considered when SS of grapes is 16.7 °B.

$$X_1 = \frac{100 \cdot a.}{100 - WR} \quad X_1 = \frac{100 \cdot 16.7}{74} = 22.5^\circ B$$

X_1 – the content of SS in grapes as a result of dehydration, °B;

a – the initial parameter of SS of grapes, °B;

$(100 - WR)$ – mass of grapes as a result of dehydration, g.

$$X_2 = \frac{100 \cdot SG}{100 - WR} \quad X_2 = \frac{100 \cdot 4.1}{74} = 5.6^\circ B$$

X_2 – increasing of SS in grapes as a result of transition of sugar from osmotic solution, °B

$$X = X_1 + X_2; \quad X = 22.5 + 5.6 = 28.1^\circ B.$$

X - SS of grapes under dehydration and transition of sugar into fruit, °B

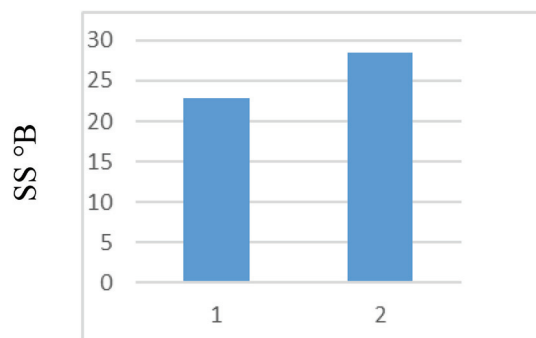


Fig. 2. Change of SS of grapes in the process of dehydration

$$X_3 = \frac{b \cdot 100}{100 + WL} - SG, \quad X_3 = \frac{70 \cdot 100}{130.1} - 4.1 = 49.7^\circ B$$

X_3 – concentration of osmotic solution after removal of a certain quantity of water and as a result of transit of water from fruit.

b – the initial concentration of the osmotic solution, $^\circ B$;

The actual indicator of the osmotic solution, $51.5^\circ B$

$$X_4 = 51.5 - X_3, \quad X_4 = 51.5 - 49.7 = 1.8^\circ B.$$

X_4 – the quantity of SS, transited from grapes – $1.8^\circ B$.

After statistical calculation, it has been revealed that one variant of dehydrated grapes, where SS is $28.1^\circ B$, insignificantly differs from average data – $27.9^\circ B$ (Tab. 3).

As a result of dehydration, the amount of solid in the grapes increases – mainly sugar and also

Table 3. Statistical data in dehydrated grapes in respect of SS $^\circ B$

max	max	n	M	$\pm\sigma$	$\pm m$	V, %
26.4	29.5	5	27.9	1.17	0.524	4.20

soluble fibrous substance, the percentage of the insoluble fibrous substance also increases. Other changes are also noted: the amount of anthocyanins reaches $70.7 \text{ mg} / 100 \text{ g}$ (Table 4). However, a small portion transits to the osmotic solution, as a result, the solution turns pink. Even though organic acids

transit into the osmotic solution, increasing acidity is mentioned in grapes.

It seems that migration of minerals occurs in osmotic solution, as a result, the quantity of combined acids decreases, and that of free acids – increases, respectively, pH is changed (Table 4).

Table 4. Chemical and phytochemical data of grapes after osmotic dehydration

SS, $^\circ B$	Titrateable acidity, g/100 g	pH	Monomeric anthocyanins, mg/100 g
27.9	0.74	3.5	70.7

As a result of conducted processes, natural sugar and the quantity of anthocyanins have increased. A jam and compote have been prepared from the obtained matter.

The energy value as compared with the product obtained by the existing technology is low to some extent: $55.0^\circ B$ and $68.0^\circ B$. Dehydration of grapes and a short period of making jam determines a relatively greater content of anthocyanins 51.3

mg/100 g (Table 5).

A compote mainly contains natural sugar, in this case, SS is 18.7 , a positive change is also observed in terms of anthocyanins. Dehydration increases the concentration in grapes; thus this parameter is relatively high in compote (Table 5).

* mass ratio of dehydrated grapes is 60 , initial parameter $16.0 \div 17.0^\circ B$;

** lemon acid is added.

Table 5. Chemical and phytochemical data of products of grapes

Product	SS, °B	Titrateable acidity, g/100 g	pH	Monomeric anthocyanins, mg/100 g
Jam	55.0	0.56	3.5	51.3
Compote	18.7*	0.70**	3.4	42.0

A quality of jam and compote from the marketing point of view is focused on sensory indicators. The obtained products are also important from this point of view. The estimation has been conducted according to the 20-point system: jam 19.2 ± 0.35 ; variation coefficient 7.3%; compote 19.0 ± 0.25 , variation coefficient 4.0%.

The transition of a soluble solid from the fruit to the osmotic solution gives it an attractive pink color, it can be successfully used in various products: iced tea, cocktail, lemonade, etc. In our case, it is used to make a compote. 5-7% solution is prepared for this purpose.

Conclusion

The technology of making jam and compote based on osmotic dehydration of table grapes is discussed;

This method holds an important place in the technology of drying and freezing - it has been shown that its use is suitable for making jams and compotes;

The functional nature of grape jam and compote obtained by integrated technology is determined by the following factors: the relative portion of fruit is increased, the amount of natural sugar is increased, a significant part of anthocyanins is preserved, the deionized grape concentrate is used as a sugar substitute;

The energy value of jam is reduced as compared with the existing technology. The quantity of SS is 55°B. In the case of a compote, a positive change is also mentioned in this respect. SS may be regulated, <20°B.

The presented technology of jam has the advantage of energy-saving efficiency due to the reduction of the boiling period.

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Rare herbs and semiwoody plants for flora of Tbilisi environs (East Georgia, South Caucasus)

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ABSTRACT

Herbaceous and semiwoody rare plants for Tbilisi environs were study. There are identified 112 rare plants, the distribution area and number of which are restricted in the vicinity of Tbilisi. They are of different bio-ecologies and characteristic plant of various ecosystems. Important part of species widespread in Georgia and they do not belong to the rare plants of Georgia. Their distribution in Tbilisi environs is due to various ecological factors. However, 23 species are rare plants not only for Tbilisi environs, but also for the flora of Georgia. Main distribution area of 13 species covers the vicinity of Tbilisi and they are not spread in other regions of Georgia or are very rare. Twenty-nine species are endemics of Caucasus, 5 of which are endemics to Georgia. List of 122 herbaceous and semiwoody rare species for Tbilisi environs identified by us are given below. Distribution area and habitats in Tbilisi environs for each species are given. Endemics of Caucasus and Georgia and life forms are indicated.

Keywords: Tbilisi environs, Biodiversity, Rare species, Endemic, Habitat, Distribution area.

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Introduction

Location and physiological conditions

Tbilisi environs are located in River Mtkvari basin in central part of South Caucasus.

Endings of large geographical units of different origin and geological age are gathered in the surroundings of Tbilisi. They are: Saguramo-Ialno and Skhalba ridges, the eastern endings of the Trialeti Range, the extreme end of the north-west and western parts of Iori plateau and Ponichala and Kumisi-Tsalaskuri plains (parts of Kvemo Kartli lowland). Hypsometrical amplitude of Tbilisi environs is about from 350 amsl to 1875 amsl [1-5].

Two types of climate are separated out in Tbilisi environs. Accordingly, there are two climatic zones shaped [2, 3]: (1) Climate with insufficient humidity, dry hot summer and mild but well expressed winter;

(2) Moderately humid climate with moderately warm summer and moderately cold snowy winter. The first zone includes the whole left side of the Mtkvari, Fonichala and Kumisi-Tsalaskuri planes and even river floodplain. The average annual atmospheric precipitation is from 380 to 530 mm and the average annual temperature is within 11.5-12.3°C. Here annual evaporation predominate the sum of precipitation. Snow cover is unstable and brief. Dryness index is equal to 2. The second climatic zone includes the mountainous part of the right side of the Mtkvari. The average annual atmospheric precipitation is from 550 to 800 mm and the average annual temperature is within 7.4-10.8°C. Snow cover is comparatively stable and long. Precipitation-evaporation ratio is equal to 1 [2, 3, 6, 7].

Grey-cinnamonic, cinnamonic and brown forest soils are distributed. Besides them, alluvial soils are developed on the terraces of rivers. Rocky and scree-

stony ecotypes and loamy and clay-sandy badlands have limited area [8, 9].

Short review of vegetation of study area

Tbilisi environs are characterised by high level of biodiversity. Approximately 1650 species of vascular plants was recorded [10, 11]. One hand, hemixerophilous and xerophilous and, second hand, mesophilous and wetlands types of vegetation are spread [12]. Xerophilous and hemixerophilous vegetation are presented by desert (semidesert), steppe and shibliak type shrubberies. Deciduous forest, shrubberies and meadow are common in mesophilous vegetation. Besides them vegetation units of rocky and scree-stony ecotypes, loamy and clay-sandy badlands and wetlands have limited area.

Aim of the research

Protection and conservation of biodiversity are one of the most pressing issues in the modern era. It is especially important to protect the natural landscapes and biodiversity around large cities, because rapid urban development and recreational load threaten both ecosystems and flora and fauna diversity. Therefore, an urgent task is to identify rare and endangered species and monitor them in urban conditions. In most cases, the focus is on the protection of fauna, and from plants to trees and shrubs. Less attention is paid to herbaceous and semiwoody plants, while the core of the floristic composition of ecosystems is mostly formed by herbaceous plants.

The aim of our research was to identify rare herbaceous and semiwoody plants of Tbilisi environs, determine their distribution area and habitats them which will allow us to develop measures for their protection and monitoring.

Objectives and Methods

A route method was used to identify rare species. Studies were conducted on the entire area of environs of Tbilisi. All main characteristic habitats of Tbilisi environs were studied. The determining criteria were the quantity and distribution range of species. The focus was on fragmentation of the distribution area. In addition to own research, literary data are used [10, 11, 13-15]. We used our previous studies in the vicinity of Tbilisi to specify the distribution ranges and habitats of species [16-23].

Caucasus and accordingly endemics of Caucasus are discussed within borders of Caucasus ecoregion [24]. Life forms of the plants follow Raunkiaer's sys-

tem [25] and Serebriakov's classification [26].

Results and Analysis

Different physiographical conditions and large altitudinal amplitude allow plants characteristic of different ecosystems to spread. Plants of different bio-ecologies in the form of individual units and not numerous populations are intruding into appropriate habitats. In some cases, the range of these plants is local, and in some cases their total area is more or less wide, although it is disjunctive and quantity of these species in a certain part of the range is small.

We have identified 122 rare herbaceous and semiwoody (semishrubs and undershrubs) plants in vicinity of Tbilisi. They are of different bio-ecologies and characteristic plant of various ecosystems. Important part of species widespread in Georgia and they do not belong to the rare plants of Georgia. Their distribution in Tbilisi environs is due to various ecological factors. Accordingly, they can be divided into following groups:

(1) **Plants of different ecotopes of upper the forest, subalpine and alpine belts (mostly plants of meadow and subalpine forests)** - *Allium kunthianum*, *Astrantia maxima*, *Asyneuma amplexicaule*, *Centaurea cheiranthifolia* subsp. *cheiranthifolia*, *Cephalaria gigantea*, *Dianthus cretaceus*, *Gladiolus caucasicus*, *Hypericum linarioides*, *Lilium szovitsianum*, *Puschkinia scilloides*, *Silene vulgaris*, *Tanacetum coccineum*, *Tephrosia cladobotrys*, etc.);

(2) **Plants of mesophilous forests** - *Actaea spicata*, *Allium ursinum*, *Anemone ranunculoides*, *Convallaria majalis* subsp. *transcaucasica*, *Doronicum macrophyllum*, *Galanthus kemulariae*, *Galanthus woronowii*, *Ornithogalum magnum*, *Paeonia caucasica*, *Paris incompleta*, etc.;

(3) **Plants of arid and semiarid ecosystems** - *Amberboa moschata*, *Asphodeline prolifera*, *Astragalus cyri*, *Astragalus stevenianus*, *Astragalus xifidium*, *Eremurus spectabilis*, *Genista transcaucasica*, *Hedysarum sericeum*, *Jurinea elegans*, *Koelpinia linearis*, *Onobrychis komarovii*, *Reseda globulosa*, *Scabiosa rotata*, *Psephellus amblyolepis*, *Sternbergia colchiciflora*, *Stizolophus coronopifolius*, *Tulipa eichleri*, etc.;

(4) **Plants of rocky, stony and scree ecotopes** - *Alopecurus textile* subsp. *tiflisiensis*, *Astragalus kadschorensis*, *Bufonia tenuifolia*, *Centaurea bella*, *Paronychia kurdica*, *Pyrethrum fruticosum*, *Silene propinqua*, *Silene solenantha*, *Silene solenantha*, *Telephium orientale*, *Tripleurospermum elongatum*, etc.;

(5) **Plants of extremely wet and wetland ecotopes** - *Alopecurus aequatialis*, *Iris pseudacorus*, *Iris spuria* subsp. *carthaliniae*, *Petasites georgicus*, etc.;

(6) **Plants of saline ecotopes** - *Salicornia europaea*, *Salsola soda*;

(7) **Plants growing on river sands and river-gravels** - *Cladochaeta candidissima*, *Glaucium flavum*.

From the identified 122 species the plants whose main distributed area covers the environs of Tbilisi and are not spread in other regions of Georgia or are very rare, are especially noteworthy. Such are: *Anthemis saguramica*, *Galanthus kemulariae*, *Glaucium grandiflorum*, *Iris paradoxa*, *Isatis subradiata*, *Minuartia hybrida*, *Minuartia intermedia*, *Papaver rhoeas*, *Phelypaea helenae*, *Tulipa biebersteiniana*, *Viola mirabilis*.

The species of the family *Orchidaceae* should be mentioned separately. There are distributed 30 species of this family in the vicinity of Tbilisi. Majority of them are more or less widespread in Georgia and some are rare species of flora of Georgia (for example: *Neottia nidus-avis*). 23 out of 27 species are presented in limited numbers in the vicinity of Tbilisi and belong to rare plants. They are of different bio-ecologies and characteristic plant of various ecosystems. They grow in as hemixerophilous (*Ophrys caucasica*, *Dactylorhiza romana* subsp. *georgica*, etc.) as mesophilous (*Anacamptis coriophora*, *Dactylorhiza urvilleana*, *Limodorum abortivum*, *Neotinea tridentata*, *Neottia nidus-avis*, *Orchis purpurea*, *Cephalanthera rubra*, etc.) and wetland (*Anacamptis laxiflora*) habitats.

It should be noted that out of 122 species 21 are rare plants not only for Tbilisi environs, but also of the flora of Georgia. Such are: *Alopecurus aequatialis*, *Anthemis saguramica*, *Asphodeline lutea*, *Bufonia tenuifolia*, *Calendula arvensis*, *Coluteocarpus vesicaria*, *Glaucium grandiflorum*, *Helianthemum georgicum*, *Iris iberica*, *Iris paradoxa*, *Isatis subradiata*, *Minuartia hybrida*, *Minuartia intermedia*, *Papaver rhoeas*, *Phelypaea helenae*, *Phelypaea coccinea*, *Roemeria refracta*, *Silene solenantha*, *Stizolophus balsamita*, *Tulipa biebersteiniana*, *Viola mirabilis*.

Endemics deserve special attention. Twenty-nine of 122 species are endemics of Caucasus, 5 of which are endemics of Georgia. One species – *Galanthus kemulariae* is local endem of Tbilisi environs (Saguramo Ridge).

List 122 herbaceous, semishrubs and undershrubs

rare species for Tbilisi environs identified by us are given below. Distribution area and habitate in Tbilisi environs and life forms for each species are given. Endemics of Caucasus and Georgia are indicated.

Abbreviations:

An. – annual
 Bian. – biannul
 Ch. – chamaephytes
 G. – geophytes
 H. – hemicryptophytes
 He. – heliophytes
 P.H. – perennial herb
 Th. – therophytes
 Ush. – undershrub

Conventional Signs

⊙ – Endemic of Caucasus
 ○ – Endemic of Georgia
 ● – Local Endemic of Tbilisi environs
 ▲ – Plant included in “Red list of Endemic Plants of the Caucasus (Solomon, Shulkina, Schatz, 013)

Pteridophyta

Dryopteridaceae

Polystichum lonchitis (L.) Roth

In ravine; in forest, probably on rocky and stony ecotopes; surroundings of Kojori (Udzo); in the environs of Tbilisi was found only once [10]. P.H. / H.

Ophioglossaceae

Ophioglossum vulgatum L.

On slopes and plane place; in oriental beech forest, forest edges and on moist meadows; Saguramo Ridge; P.H. / H.

Angiospermae Dicotyledoneae

Amaranthaceae (Chenopodiaceae)

Salicornia europaea L.

On moist salty ecotopes; was spread on the shores of saline lakes, wich in the past were in place of the Tbilisi Sea [27]. An. / Th.

Salsola soda L.

On moist salty ecotopes; was spread on the shores of saline lakes, wich in the past were in place of the Tbilisi Sea [27]. An. / Th.

Apiaceae (Umbelliferae)▲ *Astrantia maxima* Pall.

On slopes and plane place; on meadows and in forest edges; surroundings of Kojori and Kiketi. P.H. / H.

Asteraceae (Compositae)◎ ▲ *Amberboa moschata* (L.) DC.

On dry, clay, loamy and clay-sandy balands, hills and scree slopes; in different xerophilous floristic complexes; Skhalba low range and foothills of Armazi Ridge (section of Mtsketa-Dzegvi). An. or Bian. / Th. or H.

○ ▲ *Anthemis saguramica* Sosn. [*Cota saguramica* (Sosn.) Lo Presti & Oberpr.]

On slopes with brown forest and cinnamonic soils; in forest edges and shrubberies; Saguramo Ridge; P.H. / H.

Calendula arvensis L.

On dry slopes; on skeletal cinnamonic soils; in hemixerophilous shrubberies; Teleti Ridge – “In the environs of Tbilisi was found only once” [11, 28]. An. / Th.

▲ *Centaurea cheiranthifolia* Willd. [*Cyanus cheiranthifolius* (Willd.) Sojak]

subsp. *cheiranthifolia* [*Centaurea fischeri* Willd.; *Cyanus cheiranthifolius* (Willd.) Sojak subsp. *cheiranthifolius*]

On slopes and plane place; in middle mountine belt; on meadows and in forest edges; eastern endings of Trialeti Ridge (surroundings of Kojori, Satskepela and Mskhaldidi-Lisi ridges). P.H. / H.

Centaurea pseudoscabiosa Boiss. & Buhse

subsp. *glehnii* (Trautv.) Wagenitz (*Centaurea glehnii* Trautv.)

On slopes with cinnamonic soils; on dry meadows; gorge of River Vere – surroundings of Betania. P.H. / H.

◎ ▲ *Cladochaeta candidissima* (M. Bieb.) DC.

“Grows on river-gravels. Mentioned for shore of River Aragvi near Mtskheta” [11]; “Tbilisi (herbarium of Medvedev)” [29]. P.H. / H.

◎ ▲ *Doronicum macrophyllum* Fisch.

On slopes and plane place; in forests and forest edges; Saguramo Ridge [11]. P.H. / H.

◎ ▲ *Jurinea elegans* (Steven) DC.

On dry slopes; loamy and stony soils; in different hemixerophilous and xerophilous floristic complexes; Skhalba low range. P.H. / H.

Koelpinia linearis Pall.

On dry slopes; on stony cinnamonic soils,

sometaines on rocky ecotopes; on north-facing slopes of Tabori Ridge (Dabakhana). An. / Th.

Petasites hybridus (L.) G. Gaertn., B. Mey. & Scherb. [*Petasites georgicus* Manden.; *Petasites hybridus* subsp. *georgicus* (Manden.) Toman]

In moist ravines; gorge of River Tsavkisiškali. P.H. / H.

◎ ▲ *Psephellus amblyolepis* (Ledeb.) Wagenitz [*Centaurea ambliolepis* Ledeb.; *Sosnovskya amblyolepis* (Ledeb.) Takht.]

On dry slopes and hills; on loamy, clay-sandy and stony soils; in different hemixerophilous and xerophilous floristic complexes; Skhalba low range. P.H. or Ush. / H. or Ch.

Psephellus bellus (Trautv.) Wagenitz (*Centaurea bella* Trautv.)

On dry stony slopes and exposed rocky bedrocks; in tragacanthic shrubberies and in different hemixerophilous and xerophilous plant communities; Mamdaviti (Mt. Udzo), Satskepela, Mskhaldidi and Skhaltba ridges. P.H. / H.

Stizolophus balsamita (Lam.) K. Koch

On dry slopes; on skeletal cinnamonic soils; on north-facing slopes of Tabori Ridge (Dabakhana) – “Botanical garden of Tbilisi” [30]. An. / Th.

Stizolophus coronopifolius (Lam.) Cass.

On dry slopes, hills and plane places; on saline, loamy and stony grey-cinnamonic soils; in different hemixerophilous and xerophilous floristic complexes; west ending of Iori upland (Vaziani) foothills of Saguramo Ridge (Avchala). An. / Th.

▲ *Tanacetum coccineum* (Willd.) Grierson [*Pyrethrum coccineum* (Willd.) Worosch.; *Pyrethrum roseum* (Adams) M. Bieb.]

On slopes and plane place; in middle mountine belt; on meadows and in forest edges; eastern endings of Trialeti Ridge (Mamadaviti, Satskepela and etc. ridges). P.H. / H.

◎ ▲ *Tephrosieris cladobotrys* (Ledeb.) Griseb. & Schek (*Senecio cladobotrys* Ledeb.)

On slopes with brown forest soils; in forests, forest edges and in plant communities of secondary meadows; Saguramo Ridge; P.H. / H.

Tragopogon coloratus C. A. Mey.

On dry slopes; on skeletal cinnamonic soils; in plant communities of hemixerophilous shrubberies and steppe; gorge of River Tsavkisiškali – north-facing slopes of Tabori Ridge (Dabakhana). P.H. / H.

Tripleurospermum elongatum (DC.) Bornm. [*Chamaemelum elongatum* (DC.) Boiss.]

On dry slopes; on stony cinnamonic soils and rocky ecotopes; in different hemixerophilous floristic

complexes; Armazi Ridge (Armazi gorge). P.H. / H.

Brassicaceae

Coluteocarpus vesicaria (L.) Holmboe [*Noccaea vesicaria* (L.) Al-Shehbaz]

On dry slopes; on rocky, stony and scree ecotopes; in different hemixerophilous and xerophilous floristic complexes; surroundings of Mtskheta. [10, 31]. P.H. / H.

Isatis subradiata Rupr.

[*Isatis cappadocica* subsp. *subradiata* (Rupr.) P.H. Davis]

On rocky and scree slopes; Mamadaviti (Mt. Mtatsminda) and Teleti ridges. P.H. / H.

Campanulaceae

Asyneuma amplexicaule (Willd.) Hand.-Mazz.

“Soghanlugh Ridge (Krivets – TBI)” [32]. P.H. / H.

Remark: Soghanlugh Ridge is same as Teleti Ridge.

Asyneuma rigidum (Willd.) Gross.

“Tbilisi (Beideman)” [32]. P.H. / H.

Campanula saxifraga subsp. *aucheri* (A. DC.) Ogan. (*Campanula armazica* Kharadze)

On dry slopes; on rocky and stony ecotopes; in different hemixerophilous floristic complexes; foothills of Armazi Ridge (between Mtskheta and Karsani; St. Nino Monastery; Armazi gorge) [10, 33]. P.H. / H.

Caryophyllaceae

Bufonia tenuifolia L. (*Bufonia parviflora* Griseb.)

On dry slopes; on heavily skeletal cinnamonic soil; in different hemixerophilous plant communities; north-facing slopes of Tabori Ridge. P.H. / H.

Cerastium semidecandrum L.

On dry slopes; on stony and scree ecotopes; [10, 34]. An. / Th.

☉ *Dianthus cretaceus* Adams

On dry slopes; in middle mountine belt; on meadows; surroundings of Kojori [10]. P.H. / H.

☉ *Minuartia akinfiewii* (Schmahl.) Woronow

On dry slopes; on skeletal cinnamonic soils, stony and scree ecotopes; in different hemixerophilous plant communities; Skhaltba and Armazi (Armazi gorge, surroundings of vil. Dzegvi, etc.) ridges. An. / Th.

Minuartia hybrida (Vill.) Schischk.

On dry slopes; on stony, scree and rocky ecotopes; in different hemixerophilous floristic complexes;

Teleti Ridge; An. / Th.

Minuartia intermedia (Boiss.) Hand.-Mazz.

On dry slopes; on skeletal cinnamonic soils; “near Avchala” [10], “It is known only according to one copy, which Zedelmeier collected near Avchala” [35]. An. / Th.

Paronychia kurdica Boiss.

On dry slopes; on stony and rocky ecotopes; in different hemixerophilous floristic complexes; Tabori low range and etc. An. / Th.

Silene propinqua Schischk.

On dry slopes; on stony and scree ecotopes; in different hemixerophilous floristic complexes; Teleti and Tabori ridges; P.H. / H.

☉▲ *Silene solenantha* Trautv.

On dry slopes; on stony and rocky ecotopes; in different hemixerophilous floristic complexes; Mamadaviti Ridge (Mt. Mtatsminda). P.H. / H.

Silene vulgaris (Moench) Garcke (*Silene wallichiana* Klotzsch)

On slopes and plane place; in middle mountine belt; in secondary meadows and mezophilous shrubberies; surroundings of Kojori [10]. P.H. / H.

Telephium imperati L.

subsp. *orientale* (Boiss.) Nyman [*Telephium orientale* Boiss.]

On dry slopes; on stony and rocky ecotopes; in different hemixerophilous floristic complexes; Teleti, Tabori (Dabakhana) and Armazi (Martazi gorge) ridges. P.H. / H.

Cistaceae

○ ▲ *Helianthemum georgicum* Jus. & Pozdeeva

On dry slopes; on stony and rocky ecotopes; in tragacanthic plant communities [21] and in different hemixerophilous floristic complexes; Mskhaldidi Ridge [21] and etc. Ush. / Ch.

Dipsacaceae

▲ *Cephalaria gigantea* (Ledeb.) Bobrov

On slopes and plane place; in middle and upper mountine belts; on meadows and in forest edges; Kojori and Mamadaviti ridges (surroundings of Kojori), Satskepela and Mskhaldidi ridges (surroundings of vil. Bevreti). P.H. / H.

Scabiosa rotata M. Bieb. [*Lomelosia rotata* (M. Bieb.) Greuter & Burdet]

On dry slopes; on heavily skeletal cinnamonic soil; in different hemixerophilous plant communities; Mamadaviti Ridge (Mt. Mtatsminda) and etc. An. / Th.

Fabaceae

Astragalus alyssoides Lam. (*Astragalus schischkini* Grossh.)

On dry slopes; on stony cinnamonic soils; in different hemixerophilous floristic complexes; Satskepela Ridge (surroundings of vil. Bevreti), Armazi Ridge (Martazi gorge), surroundings of Kojori [10, 36]. P.H. / H. or Ush. / Ch.

○ ▲ *Astragalus cyri* Fomin

On dry slopes; on loamy and stony cinnamonic soils; in hemixerophilous floristic complexes;

▲ *Astragalus kadschorensis* Bunge

Mostly on rocky ekotopes, sometimes on stony slopes; surroundings of Kojori (Mamadaviti Ridge – Mt. Udzo, Kojori Ridge – Azeula fortress, etc.). P.H. / H.

Astragalus stevenianus DC.

On dry slopes; on loamy and stony cinnamonic soils; in different hemixerophilous floristic complexes; Mamadaviti Ridge (Mt. Mtatsminda), west ending of Iori upland (Mt. Makhata) [10]. P.H. / H.

▲ *Astragalus xifidium* Bunge

On dry slopes; on loamy and stony cinnamonic soils; in different hemixerophilous floristic complexes; Skhaltba low range. Ush. / Ch.

◎ ▲ *Genista transcaucasica* Schischkin

On dry slopes; on stony cinnamonic soils; in different hemixerophilous floristic complexes; foothills of Saguramo Ridge (section of Gldani-Mamkoda). Ush. / Ch.

◎ ▲ *Hedysarum sericeum* M. Bieb.

On dry stony slopes; in different hemixerophilous and xerophilous floristic complexes; Skhaltba low range. P.H. / H.

Medicago fischeriana (Ser.) Trautv. (*Trigonella fischeriana* Ser.)

On dry slopes; on skeletal cinnamonic soils; in different hemixerophilous floristic complexes; surroundings of Kojori [37]. An. / Th.

Melissitus brachycarpus (Fisch.) Latsch. [*Medicago brachycarpa* Fisch.; *Trigonella brachycarpa* (Fisch.) Moris]

On dry slopes; on stony grey-cinnamonic and cinnamonic soils; in different hemixerophilous plant communities; west ending of Iori upland (Mt. Makhata), surroundings of Kojori [38]. An. / Th.

○ ▲ *Onobrychis angustifolia* Chinth.

On dry slopes and plane places; on stony and loamy ecotopes; in different hemixerophilous and xerophilous floristic complexes; Skhaltba low range, surroundings of Mtskheta (slopes of Bebristsikhe

fortress). P.H. / H.

◎ ▲ *Onobrychis komarovii* Grossh.

On dry slopes and plane places; on skeletal grey-cinnamonic soils, stony and loamy ecotopes; in different hemixerophilous plant communities; west ending of Iori upland (Mt. Makhata). An. / Th.

Hypericaceae

Hypericum linarioides Bosse (*Hypericum polygonifolium* Rupr.)

On dry slopes and meadows. Meets near Kojori” [10]. P.H. / H.

Orobanchaceae

Phelypaea coccinea (M. Bieb.) Poir. [*Diphelypaea coccinea* (M. Bieb.) Nicolson]

On dry slopes; on skeletal cinnamonic and grey-cinnamonic soils; in different hemixerophilous plant communities; parasitic on the roots of species of genera *Psephellus* Cass., *Centaurea* L. and *Serratula* L.; Skhaltba, Mamadaviti (Mt. Udzo), Armazi (Armazi gorge) and Saguramo ridges, west part of Iori upland (Vaziani). P.H. / G.

Phelypaea helenae Popl. [*Diphelypaea helenae* (Popl.) Tzvelev]

On dry slopes; on skeletal cinnamonic soils; in different hemixerophilous plant communities; parasitic on the roots of species of genus *Psephellus* Cass.; environs of Mtskheta [10, 39, 40]. P.H. / G.

Paeoniaceae

◎ ▲ *Paeonia caucasica* (Schipcz.) Schipcz. [*Paeonia corallina* Retz. var. *caucasica* Schipcz.; *Paeonia daurica* subsp. *coriifolia* (Rupr.) D. Y. Hong]

On slopes with brown forest soils; in deciduous forest; Saguramo-Ialno, Mamadaviti and Sakaraulo (surroundings of Kojori) ridges. P.H. / G.

Papaveraceae

Glaucium flavum Crantz

On dry slopes; on stony cinnamonic soils; in different hemixerophilous plant communities; on north-facing slopes of Tabori Ridge – Leghvtakhevi gorge. Bian. / H.

Glaucium grandiflorum Boiss & A. Huet

On dry slopes; on stony cinnamonic soils; Mamadaviti Ridge, foothills of Saguramo Ridge (between vil. Gldani and vil. Mamkoda). Bian. / H.

Papaver rhoeas L.

On dry slopes; on skeletal cinnamonic soils; on north-facing slopes of Tabori Ridge (National

botanical garden of Georgia). An. / Th.

Roemeria refracta DC.

“Tbilisi (Overin)” [40].

Ranunculaceae

Actaea spicata L.

On slopes with brown forest soils; in deciduous forests; surroundings of Kojori. P.H. / G.

Anemone ranunculoides L.

On slopes with brown forest soils; in deciduous forests; Saguramo Ridge. P.H. / G.

▲ *Pulsatilla violacea* Rupr. (*Pulsatilla georgica* Rupr.)

On dry slopes; on stony and rocky ecotopes; Mamadaviti (Mt. Udzo), Kojori (Azeula fortress), and Mskhaldidi (surroundings of vil. Mskhaldidi) ridges. P.H. / H.

Resedaceae

▲ *Reseda globulosa* Fisch. & C. A. Mey.

Grows on dry stony slopes; meets very rare [10]. An. / Th.

Rosaceae

▲ *Alchemilla caucasica* Buser

On slopes; on meadows; surroundings of vil. Tsavkisi and vil. Bevreti [10]. P.H. / H.

◎ ▲ *Alchemilla hirtipedicellata* Juz.

On slopes; on meadows; surroundings of vil. Bevreti [10]. P.H. / H.

▲ *Alchimilla sericata* Reichb. ex Bull.

On rocky and stony slopes; in tragacanthis plant communities and other floristic complexes; Mskhaldidi (surroundings of vil. Mskhaldidi) and Kojori (Azeula fortress) ridges. P.H. / H.

▲ *Alchemilla valdehirsuta* Buser

On slopes and plane places; in forest edges and meadows; environs of Kojori and vil. Bevreti. P.H. / H.

Fragaria moschata Weston

on slopes with skeletal cinnamonic soils; in shrubberies of different types and forest edges; Teleti and Tabori (Dabakhana) ridges, foothills of Saguramo Ridge (section of Gldani-Mamkoda). P.H. / H.

Violaceae

Viola mirabilis L.

On slopes with brown forest soils; in deciduous forest; Ialno Ridge (surroundings of vil. Martkopi) [10, 41]. P.H. / H.

Monocotyledoneae

Amarylidaceae (Alliaceae)

Allium erubescens K. Koch

On slopes and plane places; on meadows; surroundings of Kojori [11]. P.H. / G.

▲ *Allium kunthianum* Vved.

On slopes and plane places; on meadows, sometimes on rocks; surroundings of Kojori [10]. P.H. / G.

Allium paradoxum (M. Bieb.) G. Don.

On slopes; on cinnamonic and brown forest soils; in deciduous forests; eastern endings of Trialeti Ridge (Teleti, Kojori and Saguramo ridges, gorge of River Vere). P.H. / G.

Allium ursinum L.

On slopes; on cinnamonic and brown forest soils; in deciduous forests; Saguramo Ridge and surroundings of Kojori. P.H. / G.

O • ▲ *Galanthus kemulariae* Kuth.

On slope with brown forest soil; in deciduous forests; Saguramo Ridge (near Zedazeni Monastery). P.H. / G.

◎ ▲ *Galanthus woronowii* Losink.

On slopes with brown forest and cinnamonic soils; in deciduous forests; Armazi Ridge (surroundings of vil. Didgori and vil. Telovani, Martazi gorge) and Saguramo-Ialno Ridge. P.H. / G.

Sternbergia colchiciflora Waldst. & Kit.

On dry slopes and plane places; on grey-cinnamonic and cinnamonic skeletal soils; in plant communities of steppe and meadow-steppe; west ending of Iori upland – Mt. Makhata, surroundings of Tbilisei sea [11], foothills of Saguramo Ridge [18], surroundings of Avchala [11]. P.H. / G.

Araceae

Arum italicum Mill.

subsp. *albispatham* Prime (*Arum albispatham* Steven ex Ledeb.)

On slopes and plane places; on brown forest and cinnamonic soils; in deciduous forests and forest edges; Mamdavit (Mt. Udzo) and Saguramo ridges. P.H. / G.

Asparagaceae

Bellevallia speciosa Woronow ex Grossh.

“Near Tabakhmela, very rare; [11]; “Tbilisi” [42]. P.H. / G.

Convallaria majalis L. [*Convallaria majalis* L. subsp. *transcaucasica* (Utkin ex Grossh.) Bordz.

[*Convallaria transcaucasica* Utkin ex Grossh.]

On slopes with brown forest soils; in deciduous forest; eastern endings of Trialeti Ridge [Saguramo, Mamadaviti (Mt. Udzo), Mskhaldidi and etc. ridges]. P.H. / G.

☉ ▲ *Ornithogalum magnum* Krasch. & Schischk.

On slopes and plane places; on brown forest soils; in deciduous forest and forest edges; Armazi (surroundings of vil. Didgori and vil. Telovani) and Saguramo ridges. P.H. / G.

Puschkinia scilloides Adams

On slopes with cinnamonic soils; in shrubberies of different types; Skhaltba and Saguramo ridges. P.H. / G.

Iridaceae

☉ ▲ *Gladiolus caucasicus* Herb.

On slopes and plane places; on meadows of middle mountine belt; eastern endings of Trialeti Ridge. P.H. / G.

☉ ▲ *Iris iberica* Steven

On dry slopes and plane places; on cinnamonic and grey-cinnamonic soils; in different hemixerophilous plant communities; west ending of Iori upland (Mt. Makhata) [11], Teleti Ridge [15], adjacent slope of Nutsbidze street and etc. P.H. / G.

Iris spuria L.

☉ ▲ subsp. *carthalinae* (Fomin) B. Mathew (*Iris carthalinae* Fomin)

In wetlands and moist meadows; shore of Lake Lisi [11], foothills of Armazi Ridge (slope of Mukhadgverdi Cemetery) and etc. P.H. / G.

▲ *Iris paradoxa* Steven

On dry slope with cinnamonic soil; in hemixerophilous shrubberies; adjacent slope of Nutsbidze street. P.H. / G.

Remark: in recent years, individual of this species is no longer recorded here.

Iris pseudacorus L.

In wetlands and shores of rivers; on shore of River Mtkvari near Zahesi [11]. Ph. / He.

Liliaceae

Fritillaria caucasica Adams

On dry slopes; on skeletal cinnamonic soils; in shrubberies of shibliak type (plant communities of *Spiraea hypericifolia* and etc.); Teleti and Mamadaviti ridges, slopes of Lake Lisi. P.H. / G.

☉ ▲ *Lilium szovitsianum* Fisch. & Ave-Lall.

On slopes; on brown forest and cinnamonic soils; in forest edges, shrubberies, adjacently of forest

edges plant communities of meadow-steppes and meadows; eastern endings of Trialeti Ridge. P.H. / G.

Tulipa biebersteiniana Schult. & Schult. f.

On slopes with cinnamonic soils; in forest edges and shrubberies; Teleti Ridge. P.H. / G.

☉ ▲ *Tulipa eichleri* Regel

On dry slope; on loamy ecotop. in hemixerophilous floristic complexes; foothills of Saguramo Ridge. P.H. / G.

Melanthaceae (Trilliaceae)

Paris incompleta M. Bieb.

On slopes with brown forest soils; in deciduous forest; Saguramo Ridge. P.H. / G.

Orchidaceae

Anacamptis coriophora (L.) R. M. Bateman, Pridgeon & M. W. Chase (*Orchis coriophora* L.)

On slopes and plane places; "In shrubberies and on moist meadows. Near Mtskheta" [11]. P.H. / G.

Anacamptis palustris (Jacq.) R. M. Bateman, Pridgeon & M. W. Chase (*Orchis palustris* Jacq.)

On moist meadows and wetlands; "On the shores of Lake Lisi and Lake Udzo" [11]. P.H. / G.

Cephalanthera damasonium (Mill.) Druce

On slopes; on brown forest and cinnamonic soils; in deciduous forest and shrubberies; Armazi and Saguramo ridges. P.H. / G.

Cephalanthera longifolia (L.) Fretsch

On slopes; on brown forest and cinnamonic soils; in deciduous forest and shrubberies; Armazi and Saguramo ridges. P.H. / G.

Cephalanthera rubra (L.) Rich.

On slopes; on brown forest and cinnamonic soils; in deciduous forest; between Kojori and Mt. Udzo. P.H. / G.

Corallorhiza trifida Châtel.

On slopes with cinnamonic and brown forest soils; in deciduous forest; Ialno Ridge. P.H. / G.

Dactylorhiza romana (Sebast.) Soó

subsp. *georgica* (Klinge) Soó ex Renz & Taubenheim [*Dactylorhiza flavescens* (K. Koch) Holub]

On slopes and plane places; on cinnamonic soils; in shrubberies of shibliak type, plant communities of meadow-steppe and forest edges; Teleti, Mamadaviti and Saguramo ridges. P.H. / G.

▲ *Dactylorhiza urvilleana* (Steud.) H. Baumann & Künkele [(*Orchis urvilleana* Steud.; *Orchis amblyoloba* Nevski; *Dactylorhiza amblylioloba* (Nevski) Aver.)]

On slopes and plane places; on brown forest and cinnamonic soils; in deciduous forests and forest edges; Saguramo, Kojori and Sakaraulo ridges. P.H. / G.

Dactylorhiza viridis (L.) R. M. Bateman, Pridgeon & M. W. Chase [*Coeloglossum viride* (L.) Hartm.]

On slopes and plane places; “in meadows and forests” [11]; Teleti and Ialno ridges. P.H. / G.

Epipactis helleborine (L.) Crantz [*Epipactis latifolia* (L.) All.]

On slopes with cinnamonic and brown forest soils; in deciduous forests and mesophilous and xeromesophilous shrubberies; surroundings of Kojori and Tskneti – Mamadaviti, Sakaraulo and Kojori ridges. P.H. / G.

Gymnadenia conopsea (L.) R. Rb.

On slopes and plane places; on meadows; surroundings of Kojori and Mtskheta [11]. P.H. / G.

Limodorum abortivum (L.) Sw. [*Centrosia abortiva* (L.) Sw.]

On slopes with brown forest and cinnamonic soils; in deciduous forests and shrubberies; Armazi and Saguramo-Ialno ridges. P.H. / G.

Neottia tridentata (Scop.) R. M. Bateman, Pridgeon & M. W. Chase (*Orchis tridentata* Scop.)

On slopes with cinnamonic and brown forest soils; in deciduous forests and shrubberies; Armazi and Saguramo ridges. P.H. / G.

Neottia ustulata (L.) R. M. Bateman, Pridgeon & M. W. Chase (*Orchis ustulata* L.)

On slopes and plane places; on cinnamonic soils; in forest edges and shrubberies, in plant communities of meadow-steppe; Mamadaviti Ridge and etc. P.H. / G.

Neottia nidus-avis (L.) Rich.

On slopes with brown forest soils; in deciduous forest; Saguramo-Ialno Ridge. P.H. / G.

Neottia ovata (L.) Bluff & Fingerh. [*Listera ovata* (L.) R. Rb.]

On slopes and plane places; on moist meadows; Armazi (environs of Mtskheta) and Ialno (environs of vil. Norio) ridges [11]. P.H. / G.

☉ ▲ *Ophrys caucasica* Woronow ex Grossh.

On slopes with cinnamonic soils; in shrubberies of shibliak type, sometimes in artificial plantations; Teleti and Mamadaviti ridges. P.H. / G.

Ophrys oestriifera M. Bieb.

On slopes and plane places; on cinnamonic and brown forest soils; in forest edges, shrubberies, adjacently of forest edges plant communities of meadow-steppes and meadows; Saguramo Ridge. P.H. / G.

Orchis mascula (L.) L.

On slopes and plane places; on different type soils; in forest edges, shrubberies, meadow-steppes and on meadows; Armazi and Saguramo ridges. P.H. / G.

Orchis purpurea Huds.

On slopes with cinnamonic and brown forest soils; in deciduous forests; eastern endings of Trialeti Ridge. P.H. / G.

Orchis stevenii Rchb. f. [*Orchis militaris* subsp. *stevenii* (Rchb.f.) B. Baumann, H. Baumann, R. Lorenz & Ruedi Peter]

On slopes and plane places; in deciduous forests, as well on moist ecotopes; Mamadaviti and Saguramo ridges; P.H. / G.

Spiranthes spiralis (L.) Chevall.

On slopes and plane places; on cinnamonic soils; in plant communities of secondary meadow-steppe and artificial plantations; foothills of Saguramo Ridge (surroundings of Avchala settlement – near Petre Apostle Church) [18]. P.H. / G.

Steveniella satyrioides (Spreng.) Schltr.

On slopes and plane places; on cinnamonic and brown forest soils; in deciduous forests and shrubberies; Teleti, Armazi and Saguramo-Ialno ridges. P.H. / G.

Poaceae (Gramineae)

Alopecurus aequalis Sobol.

“Was Found only once on the shore of Udzo Lake” [11]. An. / Th.

Alopecurus tiffisiensis (G. Westb.) Grossh. [*Alopecurus textilis* subsp. *tiffisiensis* (G. Westb.) Tzvelev]

On dry slopes; rocky and stony ecotopes; in different hemixerophilous plant communities; Teleti and Tabori ridges, environs of Mtskheta. Bian. or P.H. / H.

Bromopsis variegata (M. Bieb.) Holub (*Bromus variegatus* M. Bieb.)

On slopes; on meadows. near Kojori. P.H. / H.

Xanthorrhoeaceae

Asphodeline lutea (L.) Rchb.

On dry slopes; on skeletal cinnamonic soils and stony ecotopes; in different hemixerophilous and xerophilous floristic complexes; Saguramo-Ialno Ridge. P.H. / G.

☉ ▲ *Asphodeline prolifera* (M. Bieb.) Kunth [*Asphodeline dendroides* (Hoffm.) Woronow]

On dry stony slopes; “on the left side of River Mtkvari” [11]. An. / Th.

Eremurus spectabilis M. Bieb.

On dry slopes; on stony and scree ecotopes; in xerophilous plant complex; foothills of Armazi Ridge (Martazi gorge). P.H. / G.

Conclusion

1. There are identified 122 rare herbaceous and semiwoody (semishrubs and undrshrubs) plants for Tbilisi environs. Their distribution area and number are restricted in the environs of Tbilisi. They are of different bio-ecologies and characteristic plant of various ecosystems.

2. Important part of these species widespread in Georgia and they do not belong to the rare plants of Georgia. Their distribution in Tbilisi environs is due to various ecological factors.

3. 21 species are rare plants not only for Tbilisi environs, but also of the flora of Georgia.

4. Main distribution area of 11 species (*Anthemis saguramica*, *Galanthus kemulariae*, *Glaucium grandiflorum*, *Iris paradoxa*, *Isatis subradiata*, *Minuartia hybrida*, *Minuartia intermedia*, *Papaver rhoeas*, *Phelypaea helenae*, *Tulipa biebersteiniana*, *Viola mirabilis*) covers the vicinity of Tbilisi and they are not spread in other regions of Georgia or are very rare.

5. 33 of 122 species are endemics of Caucasus, 5 of which are endemic of Georgia. One species – *Galanthus kemulariae* is local endemic of Tbilisi environs (Saguramo Ridge).

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The same data must not be repeated in tables, graphs and a text.

4. Arrangement of illustrations:

Pictures and photos must not be glued, they must be attached at the end of a paper.

Pictures must be drawn in Indian ink on white paper or using computer graphics.

Pictures must be very distinct. Legends must be placed according to a text.

Comments on picture margins must be brief. Photos must be presented on glossy paper in two copies (xerox copies will not be accepted) not damaged.

Pictures and photos must be numbered on back sides and the names of authors must be written in pencil.

Comments to photos and pictures in a text must coincide with their contents.

5. Arrangement of illustrations and Tables in a text must be indicated on the margins with pencil.

6. Indication of references:

For papers: surnames and initials of the authors, title of the article, journal, volume, number, year, pages.

For books: surnames and initials of the authors, book, place of publishing, year, total number of pages.

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