AGRISCIENCE AND TECHNOLOGY
Armenian National Agrarian University
АГРОНАУКА И ТЕХНОЛОГИЯ
International Scientific Journal
ISSN 2579-2822

UDC 656.13
doi: 10.52276/25792822-2024.2-106

The Influence of the Stationarity Property on Traffic Flow Control

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ARTICLE INFO

Keywords:
ATCS,
coordination program,
intensity,
phase shift,
stationarity

ABSTRACT

This study provides an overview of traffic control methods using automated traffic control systems (ATCS). The main approach highlighted during the analysis is the application of rigid multi-program management, including a library of coordination programs. The study also found a dependence of the period of operation of each coordination program on the state and intensity of traffic flow (TF), noting an increase in the period of stationarity with an increase in the intensity of TF. Based on the system analysis, a mathematical dependence of the control parameter on the intensity affecting the efficiency of TF management is proposed. The results obtained can be applied to optimize the operation of the automated control system and develop effective traffic management strategies.

Introduction

The use of new technologies and the calculation of traffic control modes was studied in many research works. As a result, the main operating modes of the automated control system and calculations of traffic light control parameters were established in accordance with changes in the traffic characteristics of the TF (Braylovsky and Granovsky, 1975; Kapitanov and Khilazhev, 1985; Kremenets, 2005, Petrov, 2020).

A variety of strategies are used to optimize the use of road infrastructure. These approaches include the introduction of traffic restrictions in certain areas, access control to urban areas, the introduction of a toll system, the organization of paid parking and tougher penalties for violations of parking and stopping rules. In addition, improving public transport and creating comfortable conditions for its use are also important aspects of improving the efficiency of the transport system. All these measures are aimed at ensuring more efficient and

sustainable use of urban infrastructure, which contributes to improving the quality of life of citizens and improving the environmental situation in the city (Mikhailov, 2014). The operation of the automated control system for 40 years has shown that not all parameters of traffic light regulation are clearly spelled out. The period of validity of one PC (program coordination) mode is mentioned indirectly in all works. This is due to the fact that the TF can be in one of 3 states (Petrov, 2020).

- free state,
- group state,
- bound state.

When transitioning from one TF state to another, the significance of its properties changes:

- stochasticity;
- stationarity;
- breakup of groups;
- formation of groups.

All of the listed properties of the TF, except stationarity, are taken into account when calculating the PC. The stationarity property of a TF is the existence of a period of time when the traffic intensity of a TF can be considered constant. Analysis of statistical data on changes in the intensity of traffic of the TF, obtained from the results of the functioning of the automated control system shows that the period of stationarity of the TF changes throughout the day and depends on the state of the TF (Petrov, 2020).

To achieve this goal, it is necessary to solve the following tasks:

- analyzing the daily change in traffic intensity on urban highways;
- setting the range of changes in the intensity of TF per day;
- determining the minimum and maximum period of stationary TF;
- predicting the dependence of the period of stationarity on the intensity of TF.

As a result of solving the set tasks, it will be possible to improve the following performance indicators of the automated control system:

- reducing the number of stops in the area where the automated control system operates;
- reducing vehicle delays;
- reducing the likelihood of congestion;
- reducing the length of the next vehicle.

The main task is to form a hypothesis of the dependence of the period of action of the PC on the intensity of the TF movement based on the analysis. The object of the study is the movement of TF along the urban road network of the city.

Materials and methods

The choice of the traffic flow control mode (road traffic) must be carried out in accordance with the values of the TF characteristics – intensity, speed, density. The main controlled characteristic is the intensity of TF, which varies throughout the day, week and year (Braylovsky and Granovsky, 1975). As an example, we consider changes in the intensity of traffic flow obtained on Voronezh Moskovsky Avenue (ATCS introduced in 2018) (3 lanes in each direction, average roadway width 25.3 m), which is shown in Figure 1.

The analysis of the graphs shows a constant change in the intensity of TF and the transition from one state to another, which implies the need for timely change of traffic control modes. Changes in the intensity of TF movement lead to changes in such properties as stationarity and stochasticity. In the free state of TF ($\lambda < 350$ aut./h), stationarity and stochasticity have little effect on the change of control modes. With a connected TF ($\lambda > 650$ aut./h), these properties must be taken into account when choosing the moment of changing the control modes and the period of its operation. The period of operation of this mode can range from 30 minutes (with two-phase regulation) to 2 hours.

The main control actions within the framework of a single regulatory regime (coordination program – PC) of the ATCS are:

- cycle duration for PC;
- the duration of the phases in the cycle;
- the magnitude of the phase shift;
- the validity period of the PC;
- time to turn on the PC.

The discrepancy between the listed control actions of the current transport situation leads to the formation of congestion for 30-60 minutes. This is often observed in the associated state of TF. Currently, on urban highways, the associated state of TF is observed from 9:00 to 19:00 hours.

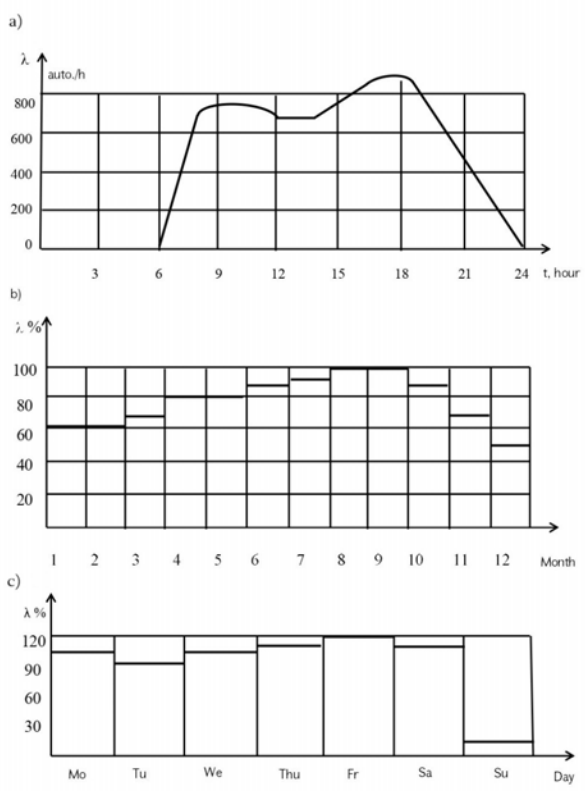

Figure 1. Change in traffic intensity of the TF 2022 a) during the day b) during the year c) during the week *(composed by the authors)*.

To solve the assigned tasks, the following actions must be performed:

- considering the procedure for changing modes;
- formulating requirements for measuring the intensity of TF traffic;
- considering the algorithm for changing the PC;
- formulating requirements for calculating the validity period of the PC.

The main modes of traffic regulation by means of ATCS are:

- single-program coordinated management;
- multi-program coordinated management;
- adaptive coordinated management;
- dispatch control.

The most common traffic regulation regime of the ATCS is strict multi-program coordinated management. To implement this mode, you need a PC library and a PC changeover map. The PC library is calculated in advance based on statistics on changes in traffic intensity on urban highways. Data on changes in the intensity of TF movement can be obtained in advance using a combination of the following measurement methods:

- full-scale method,
- transport detectors (systems and portables),
- video cameras.

The road video surveillance system is an integrated platform designed for operational monitoring and management of the road situation. It carries out continuous monitoring of the state of road infrastructure, collects data on traffic flow and emergency situations, as well as promptly alerts dispatchers about incidents. The functionality of this system is implemented using advanced video analytics technologies, which allow to automatically process video data and identify various anomalies and situations on the roads (Agureev and Atlas, 2012).

The main advantage of rigid multi-program coordinated control is the ability to obtain data for calculating modes in advance. During the operation of the automated control system, the error in measuring data on the traffic intensity of the TF should not exceed 5 %. Otherwise, an error will occur when selecting the mode (PC) and, as a consequence, the following problems will arise in the group and connected state of the TF:

- incorrect distribution of the green signal in the cycle and, as a consequence, disproportion of TF queues in different phases;
- violation of the “Green Wave”;
- occurrence of congestion.

The following factors influence the operating error of vehicle detectors:

- the presence of snow (closes the marking);
- TF intensity;
- light level;
- increased humidity.

These factors affect the measurement error up to 100%.

Mathematical modeling of traffic flows is becoming an integral part of the development of automated traffic control systems (ATCS). The study of the dynamics of both individual vehicles and flows in general at various

levels - from micro to macro - using a variety of physical and mathematical models, provides forecasting of the overall situation on the roads and the development of effective algorithms to minimize traffic delays (Agureev, et al., 2013). These studies are inextricably linked with the availability of modern technological solutions and software, which provides a wide range of opportunities for testing and approbation of various automated transport infrastructure management systems. Thus, the adaptation of mathematical models to a modern technological base is an important step for the successful implementation of traffic management systems (Gasnikov, 2013).

Results and discussions

Thus, in order to ensure the high-quality operation of the automated control system in the strict multi-program control mode, the following conditions must be met:

- statistics on changes in traffic intensity should be collected in advance;

- measurements should be repeated with a range of readings of no more than 5 %.

Based on the system analysis of the work and the results of the previous section, the following statements can be made:

- during the day, the TF goes from a free state to a group state: connected and back;

- in the free state of the TF, the traffic intensity of the TF increases rapidly since the combination of intensities in all phases of the intersection is significantly less than the value of the saturated flow:

$$\sum_{i=1}^{n} \lambda_i << S, \qquad (1.1)$$

where, λ_i- the intensity of TF in the i-th phase, n - number of phases, S - the value of the saturation flow.

- in the bound state of TF, the intensity of TF changes very slowly since the totality of intensities in all phases of the intersection is close to the value of the saturation flow:

$$\sum_{i=1}^{n} \lambda_i \to S. \qquad (1.2)$$

The analysis of the graph of changes in vehicle traffic intensity in Fig. 1 (a) confirms the conclusions drawn.

Thus, summarizing the conclusions drawn, the following hypothesis can be formulated:

- the period of operation of each mode (PC) should increase with increasing traffic intensity;

- to solve the problem, it is proposed to use the following equation:

$$y = ax + b, \qquad (1.3)$$

where, y is the validity period of the PC, x is the traffic intensity of the TF, a and b are constant coefficients.

Currently, with traffic light regulation of the entire road network of the city of Yerevan, traffic at intersections is working under strict traffic light regulation (in peak time mode), as a result of which during off-peak hours (10:15-12:00, 15:00-16:30 and 21:00-8:00) there are major delays caused by an excess of green signals on secondary routes. During rush hours (8:30 - 10:00, 13:00 - 14:30 and 17:00 - 19:00) almost 70-75% of the road network (9 points on the 10-point scale of the Yandex map) directions are considered dense, overloaded situations caused by high traffic volumes (Sargsyan and Khachatryan, 2023).

Experimental studies conducted on Mashtots Ave. (3 lanes in each direction, average roadway width 24.8 m) in Yerevan from September 10 to 20, 2023, made it possible to obtain statistical data on the intensity of TF and the time period of their preservation (Fig. 2), which will be changed after the introduction of the ATCS, and will change the period of activity of the given project, depending on the stationarity of the TF.

After processing the data using the least squares method, the regression equation and the values of the coefficients a and b in the formula 1.3 were obtained.

$$t = 0.1\lambda - 5, \qquad (1.4)$$

where, t– the validity period of the PC, λ – intensity of the TF.

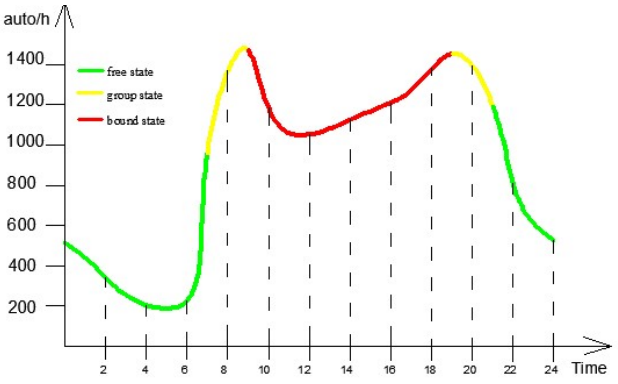

Figure 2. TC condition and average traffic intensity *(composed by the authors)*.

Conclusion

Thus, the following conclusions can be drawn:

A review of the methods of traffic control by means of automated control systems has been performed. It is established that the most frequently used mode is rigid multi-program management, which consists of a library of coordination programs. The task of the study is set up.

Based on the system analysis, the dependence of the period of operation of each PC (the period of stationarity) on the state and intensity of TF has been established. It was found out that with an increase in the intensity of TF movement, the stationary period increases from 30 minutes to 2 hours.

A mathematical dependence of the control parameter affecting the efficiency of TF control intensity is proposed.

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Declarations of interest

The authors declare no conflict of interest concerning the research, authorship, and/or publication of this article.

Accepted on 21.03.2024
Reviewed on 07.05.2024

AGRISCIENCE AND TECHNOLOGY
Armenian National Agrarian University
ԱԳՐՈԳԻՏՈՒԹՅՈՒՆ ԵՎ ՏԵԽՆՈԼՈԳԻԱ АГРОНАУКА И ТЕХНОЛОГИЯ
International Scientific Journal
ISSN 2579-2822

UDC 528.443(479.25)
doi: 10.52276/25792822-2024.2-111

The Necessity to Calculate the Impact of Climate Risks on Determining the Cadastral Assessment of Agricultural Lands

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ARTICLE INFO

Keywords:
agricultural lands,
cadastral value,
climate risks,
land rent,
net income

ABSTRACT

Armenia, with its entire territory, is considered the most sensitive country to climate change. The land tax rate for agricultural lands is determined at 15 percent of the estimated net income determined by their cadastral assessment. The cadastral assessment of agricultural lands in the Republic of Armenia was carried out in 2002-2004. During the assessment, the materials of land management, soil science, geobotanical, and other studies and research conducted in the 1970-1980s were taken as a basis. The article presents the results of research and analysis conducted by the authors during 2020-2023, on the impact of climate risks on the yield and quality of crops on agricultural lands in the Republic of Armenia. As a result of the research, it turns out that among climate risks, the greatest damage to agricultural lands in the Republic of Armenia is caused by frost, hail, and drought, which affects the quantity and quality of crops from agricultural lands, and consequently the income received, which, however, does not reduce the tax burden of the landowner. As a result of the research, to modernize the assessment methodology in the process of calculating net income, it is recommended to adopt the revised calculation method developed and proposed by the authors using risk reduction coefficients (climate risks).

Introduction

Armenia, with its entire territory, is considered the most sensitive country to climate change. The annual increase in air temperature, increase in the frequency and intensity of extreme weather conditions (droughts, frosts, hail, etc.), as well as a significant decrease in precipitation have an obvious negative impact on gross agricultural output.

The land tax rate for agricultural lands is determined at 15 percent of the estimated net income determined by their cadastral assessment (Land Code of the Republic of Armenia, 2001). The cadastral assessment, of agricultural lands in the Republic of Armenia was carried out in

2002-2004; during the assessment, the materials of land management, soil science, geobotanical, and other studies and research conducted in the 1970-1980s were taken as a basis. The Decision of the Government of the Republic of Armenia No. 29 of January 13, 2022, "On approval of the cadastral value of agricultural lands" adopted the cadastral values of agricultural lands based on net incomes and cadastral values that were adopted by the Decisions of the Government of the Republic of Armenia No. 237 of July 3, 1997, No. 1101 of July 25, 2002, and were determined by the Decision of the Government of the Republic of Armenia No. 898 September 2, 2016 (Ezekyan, 2014; Decision of the Government of the Republic of Armenia No. 237 of July 3, 1997; Decision of the Government of the Republic of Armenia No. 1101-N July 25, 2002; Decision of the Government of the Republic of Armenia No. 29 of January 13, 2022).

By the observations that we have carried out in recent years, it turns out that every year in the Republic of Armenia 30-35 thousand hectares of arable lands, and perennial plantings suffer from different climatic disasters: spring frosts, hail, and drought.

Every year, 10-15 % of the Republic's perennial plantings are damaged by hail; in some cases, crop losses in hail-damaged areas amount to 80-100 %. In addition, hail-damaged crops lose their marketability, which makes them difficult to sell, as a result, the incomes of land users decrease significantly (Recommendations for reducing the risks of natural and man-made disasters that damage agriculture in the Republic of Armenia, 2015).

All of the said disasters directly affect the quantity and quality of obtained crops per unit area, and therefore, the net incomes from the land.

Materials and methods

Over the past 30 years, along with the development of market relations, the natural properties of agricultural lands, productivity, costs of their cultivation, as well as the types of cultivated crops and geography have changed in the Republic of Armenia. Research and analysis, conducted in 2020-2023, to modernize the methodology of the cadastral assessment of agricultural lands, show that the climate risks have a significant impact on the yield and quality of crops in the Republic of Armenia, herewith especially crops are seriously damaged by spring frosts, hail, and drought. Analysis was carried out based both on the results of field works and by studying statistical data on agricultural insurance sold in the Republic of Armenia since 2020.

Agricultural insurance in Armenia was started in the fall of 2019 and began in 2020. In 2020, only 5 crops were insured: grapes, apricots, apples, peaches and grain crops. Since 2021, the number of insured crops has increased to 9: watermelon, melon, plum, and potato have been added. The insurance territories were expanded to all marzes (provinces) of the Republic of Armenia, and all communities of Armenia were allowed to insure perennial plantings and cultivated areas (www.insurebusiness.am).

In 2022, to the list of crops that were insured was added another one - cherry, and there was also added the insure of grains against the risk of drought. Insurance contracts in the Republic of Armenia are concluded against the risks of hail, spring frosts, and fires. The graphs below show the number of concluded insurance contracts by year, the number of contracts applied for compensation, and the total amount of compensation depending on the degree of damage.

Research shows that 15 insured contracts received compensation in the period 2020-2023 under an insurance contract concluded only for insured crops (grapes, apricots, apples, peaches, cherries, watermelons, melons, plums, potatoes, and agricultural grains) -20 %, and according to the analysis, the average degree of damage (depending on the risk and crop) of most compensations ranged from 40-50 %.

As can be seen from Figure 1, after the implementation of the agricultural insurance system in 2023, compared to 2020, the number of concluded contracts increased by approximately 6.5 times (www.aina.am).

As can be seen from Figure 2, the degree of damage, caused to crops insured against frost, hail, and drought in the Republic of Armenia, was significant, and the cost of the insurance compensation received was about 1.9 billion drams, which is approximately 12.4 times more than the received amount of compensation of insured contracts in the Republic of Armenia during 2020.

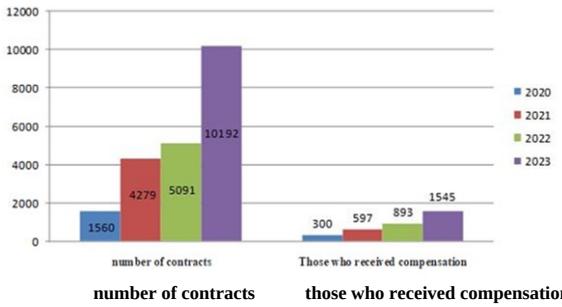

Figure 1. The number of contracts applied for compensation *(composed by the authors)*.

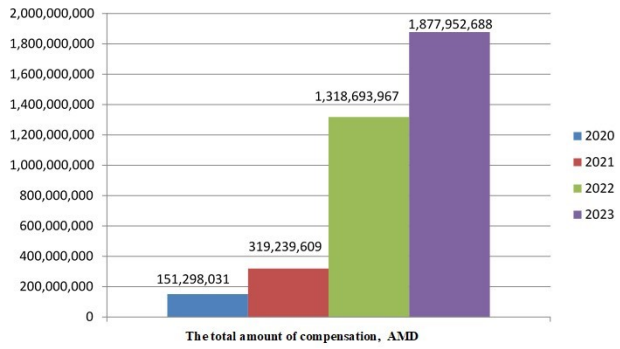

Figure 2. The total monetary value of contracts applied for compensation from concluded contracts in the Republic of Armenia, by years *(composed by the authors)*.

According to different predictions, if radical changes are not made before 2030, agricultural yields will decrease by 8-14%. The negative impact of climate changes on this indicator is mainly due to the direct impact of changes in temperature and precipitation, an increase in the need for irrigation water, and a reduction in irrigation water reserves in conditions of decreased precipitation and high evaporation, as well as an increase in the frequency, intensity, and duration of climate risks and expansion of spatial distribution.

According to predictions, by 2030, as a result of climate changes, the total area of pastures in Armenia will decrease (the area of pastures in the subalpine and alpine zones by 19-22 %), and the volume of harvest will decrease by 4-10 %. As a result of all this, feed production volumes will decrease, which in turn will hurt the livestock sector (www.e-draft.am/ru).

Figure 3 shows the research conducted by the Center for Hydrometeorology and Monitoring in 2022. As can be seen from Figure 3, severe and very severe droughts were observed in the Ararat Valley from the first and second decades of June until the end of September. At stations in the foothills, mountains, and highlands, severe and very severe drought began in the third decade of July and continued intermittently until the end of September at some stations, except Aparan, Tsakhkakhovt, and some northern regions, where drought conditions were weaker (www.meteomonitoring.am).

All of the above climate risks have and will have a significant impact on the productivity of agricultural lands in the Republic of Armenia.

Station	Height, m	May			June			July			August			September		
		I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
Bagratashen	448	5	5	5	3	3	4	4	3	1	1	1	1	2	2	3
Meghri	661	3	3	3	2	1	1	1	1	1	1	1	1	1	1	1
Ijevan	695	5	5	5	5	5	5	5	2	1	2	2	2	2	2	3
Ararat	819	1	4	2	1	1	1	1	1	1	1	1	1	1	1	1
Armavir	861	3	5	4	2	1	1	1	1	1	1	1	1	1	1	1
Yerevan-Agro	942	3	5	5	3	2	2	2	1	1	1	1	1	1	1	1
Urtsadzor	1064	4	5	5	2	2	2	2	2	1	1	1	1	1	1	1
Areni	1066	5	5	5	2	2	2	2	1	1	1	1	1	1	1	1
Dilijan	1256	5	5	5	5	5	5	5	5	1	3	3	2	3	3	5
Vanadzor	1376	5	5	5	5	5	5	5	5	1	3	3	2	3	3	5
Gyumri	1528	5	5	5	5	5	5	5	4	2	2	2	1	2	3	5
Sisian	1615	5	5	5	5	5	5	5	1	1	2	2	1	1	1	1
Fantan	1799	5	5	5	5	5	5	3	2	1	1	1	1	1	1	2
Aparan	1899	5	5	5	5	5	5	5	5	5	5	5	3	2	2	2
Martuni	1943	5	5	5	5	5	5	5	3	1	1	1	1	1	1	1
Gavar	1950	5	5	5	5	5	5	5	4	2	3	3	3	1	1	1
Amberd	2071	5	5	5	5	5	5	3	1	1	1	1	1	1	1	2
Tsaghkahovit	2101	5	5	5	5	5	5	5	5	2	5	5	3	3	3	5

1 - very severe drough, 2 - severe drough, 3 - medium drough, 4 - weak drough, 5 - absence of droughts

Figure 3. The zoning of the observing drought, 2022 *(composed by the authors)*.

Results and discussions

As a result of analysis and research, we concluded that the cadastral value and net income of agricultural lands need to be updated and modernized no earlier than once every 3 years and no later than once every 5 years, and herewith there is also a necessity for implementation in existing land-cadastral zones and subzones of new modern works of zoning, after the completion of which the calculating of the impact of climate risks during the process of the cadastral assessment of agricultural lands will have national significance.

As already mentioned, frost, hail, and drought are the most destructive climatic disasters for the agricultural lands of the Republic of Armenia, directly affecting the quantity and quality of the harvest obtained from agricultural lands, and therefore the income, which, however, does not reduce the land owner's burden of the tax.

Table. Analysis of the reducing coefficients of climate risks

Climatic Disasters	Reducing Coefficients
Frost	0.1
Hail	0.1
Droughts	0.1

*Composed by the authors.

For example, according to the submitted proposal, the estimated net income value of irrigated arable land of the 1st class of the Urts-Kotayk-Shamiram land-cadastral zone is 145 900 AMD, and if the latter has been subjected to frost once during the period 3-5 years, then its net income will be:

$$145900*0.9=131310.$$

If the latter was subjected to each of the three above-mentioned disasters during the period under review, then the value of its net income will be:

$$145900*(1-(0.1f+0.1h+0.1d))=145900*0.7=102130,$$

where: 0.1f – coefficient that applied as a result of the impact of frosts, 0.1 h - coefficient that applied as a result of the impact of hails, 0.1d - coefficient that applied as a result of the impact of droughts.

If the region in question was subjected to hail annually during the period under review, then the value of the latter's net income will be:

$$145900*(1-(0.1h+0.1h+0.1h))=$$
$$=145900*0.7=102130.$$

Conclusion

The research and analysis conducted by us during 2020-2023 provide the basis to conclude that climatic disasters have a significant impact on the productivity and quality of crops in the Republic of Armenia, and the calculation of this impact in the process of calculating the net income of agricultural lands is necessary with to modernize the methodology of the cadastral assessment, adopt the proposed new calculation methodology by the reducing coefficients of climate risks.

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Acknowledgements

This analysis was carried out with the financial support of the Higher Education and Science Committee of the Ministry of Education, Science, Culture and Sport of RA – within a scientific topic coded 21T-4C249.

Declarations of interest

The authors declare no conflict of interest concerning the research, authorship, and/or publication of this article.

Accepted on 07.03.2024
Reviewed on 06.05.2024

AGRISCIENCE AND TECHNOLOGY
Armenian National Agrarian University
ԱԳՐՈԳԻՏՈՒԹՅՈՒՆ ԵՎ ՏԵԽՆՈԼՈԳԻԱ АГРОНАУКА И ТЕХНОЛОГИЯ
International Scientific Journal
ISSN 2579-2822

UDC 634.1:632.654+634.22:632.654 doi: 10.52276/25792822-2024.2-116

The Habitation and Damage of Mite in Apple and Plum Tree Orchards of Armavir Region

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ARTICLE INFO

Keywords:
apple tree,
habitation,
harmfulness,
phytophagous,
plum tree

ABSTRACT

In 2021-2022, a study of herbivorous (phytophagous) mite habitation and harmfulness was conducted in apple and plum orchards in the Armavir region (RA). Research findings of two-year scientific experiments confirmed that between the two apple varieties the Star Crimson variety had the highest habitation rate of Hawthorn Red Spider Mite (Tetranychus viennensis Zacher), specifically 52.7 % in the first year, and 55.5 % in the second year. Among the three plum varieties, Vengerka Italian had the highest habitation rate (49.5 and 53.2 %, respectively) of common spider mites (Tetranychus urticae Koch). Research findings also confirm that at the peak of leaf damage, compared to the Golden Delicious apple variety, the damage caused by Hawthorn Red Spider Mite to the leaves of the Star Crimson apple variety was high in 2021-2022 (43.5 % and 45.0 % respectively). There was relatively high damage caused by Hawthorn Red Spider Mite to the “Vengerka Italian” variety in 2021 and 2022 (39.9 % and 41.0 %, respectively). Effective control measures against phytophagous mites with high habitation in apple and plum orchards will be developed and offered to farmers.

Introduction

Herbivorous (phytophagous) mites are considered one of the primaries of pest and disease control since they cause significant damage to fruit trees (Dilbaryan and Kocharyan, 2014; Manvelyan and Asatryan, 2018).

In fruit trees, phytophagous mites actively develop in various organs (mainly leaves, sometimes leaves, sometimes fruits) causing some pathological processes. Due to mite nutrition, many vital biological processes in plant cells, include photosynthesis and respiration. In addition, metabolism almost stops, cells are mostly empty and filled with air, and the cell wall turns gray. Over time, necrotic (dead tissue) spots appear on the leaves of heavily damaged trees, multiplying and coalescing, causing the leaves to dry out and fall prematurely. Due to the reduction

of photosynthetic surfaces, fruit quality drops. The offshoot rate of growth slows down, they become pale, sometimes non-fruitful (Arutyunyan and Dilbaryan, 1986; Melikyan, 2007).

Among the many orchards studied in the scope of the scientific experiments over several years, apple and plum trees were singled out as the most inhabited and the most damaged by herbivorous mites. According to the research findings, a total of 9 types of harmful mites were found and identified, 7 of which were tetranychoid and 2 were tetrapod (Terlemezyan and Asatryan, 2021).

Materials and methods

Apple and plum varieties were included in the 2021-2022 experiments. The goal was to identify the habitation and damage of the mentioned fruit orchards by herbivorous mites. During the vegetation period, 50 leaves (in several cases also young branches and fruits) from 20 trees of each fruit type were counted every 7 days.

The assessment of the habitation (damage) of different varieties of apple and plum by herbivorous ticks was performed on the following scale:

0 points - leaves, as well as other vegetative and generative organs, that were not infested with mites. 1 point - leaves and sometimes other vegetative and generative organs inhabited or damaged by mites on 5% of their surface.

2 points - leaves, and, in some cases, other vegetative and generative organs, with 6-25% of the surface covered in mites.

3 points - leaves, and sometimes other vegetative and generative organs, with 26-50% of the surface infested or damaged by mites.

4 points - leaves and, in some cases, other vegetative and generative organs infested or damaged by ticks on more than 50% of their surfaces.

The assessment of the habitation of different apple and plum varieties was performed according to the following scale:

0 points – leaves on which no mites were found,

1 point - leaves on which 1 to 10 mites were found,

2 points – leaves on which 11 to 20 mites were found,

3 points - leaves on which 21 to 30 mites were found,

4 points – leaves on which 31 or more mites were found (Manvelyan, 2004; Melikyan, 2007; Harutyunyan, 2018).

The habitation and damage of ticks in leaf mass fruit trees was determined by the following formula:

$$X = \frac{\sum abc}{n \cdot 4} \cdot 100\% ,$$

where X – is the habitation of leaves with ticks or the harmfulness, $\sum abc$– is the sum of the points, n – is the total number of counted leaves or other observed organs, 4 – is the maximum points value (Livshits, 1964; Terlemezyan, et al., 2022).

Results and discussions

During the 2021-2022 vegetation period, nine species of harmful mites were observed and identified on five varieties of apple and plum trees. seven of which were tetranychoid and two were tetrapod. There were nine mite species observed on different varieties of apple and plum, but two caused the most damage. These two mite species are the Hawthorn Red Spider Mite and the Common Spider Mite. The indicators of habitation and habitation degree of the Hawthorn Red Spider Mite and the Common Spider Mite observed on different apple and plum trees in 2021-2022 are presented in Tables (1 and 2).

According to Table 1, mite habitation and habitation degree increased in 2022 compared to 2021. In particular, if, in 2021, the indicators of the Hawthorn Red Spider Mite were 52.7 % and 48.0 % in the Star Crimson and Golden Delicious varieties, then, in 2022, the indicators of the latter were 55.5 % and 49.1 %, respectively. In the case of the two apple varieties with Hawthorn Red Spider Mite, the indicators were 60.1 % and 56.8 % in 2021 and 63.8 % and 57.4 % in 2022, respectively.

Table 1. The habitation and habitation degree of apple varieties with Hawthorn Red Spider Mite (Aygevan, 2021–2022)*

	Variety	Habitation, %		Habitation degree, %	
		2021	2022	2021	2022
Apple tree	Star Crimson	52.7	55.5	60.1	63.8
	Golden Delicious	48.0	49.1	56.8	57.4

*Composed by the author.

Research findings confirm that the most sensitive varieties were the Star Crimson apple and Vengerka Italian plum. The highest habitation rates and habitation degree of Hawthorn Red Spider Mite and Common Spider Mite were recorded, respectively.

Table 2 shows a similar pattern for the three plum varieties (Vengerka Italian, Vengerka Domestic, and Victoria).

Table 2. The habitation and habitation degree of plum varieties with the Common Spider Mite (Aygevan, 2021–2022)

	Variety	Habitation, %		Habitation degree, %	
		2021	2022	2021	2022
Plum tree	Vengerka Italian	49.5	53.2	56.7	58.8
	Vengerka domestic	47.0	51.8	53.1	56.2
	Victoria	43.9	46.4	50.1	53.5

*Composed by the author.

In 2021, the habitation of the Vengerka Italian variety with Common Spider Mite was 49.5 %, and the habitation degree was 56.7 %. In the same year, Vengerka Domestic and Victoria varieties had habitation indicators of 47.0 % and 43.9 %, respectively, and habitation degree of 53.1 % and 50.1 %, respectively.

In 2022, the following indicators were recorded in terms of habitation: Vengerka Italian - 53.2 %, Vengerka Domestic-51.8 %, and Victoria - 46.4 %. Regarding the habitation degree, the indicators were the following: Vengerka Italian - 58.8 %, Vengerka Domestic - 56.2 %, and Victoria - 53.5 %. Of the five studied varieties, only the Star Crimson apple and Vengerka Italian plum varieties had high habitation indicators. Relatively low habitation degrees were recorded in Golden Delicious apple, Vengerka plum, and Victoria varieties, which is mainly due to the morphological and biochemical differences between the varieties (in particular the softness of the lower leaf skin, the thickness of the cell wall in the epidermis layer, the maturity of the plant tissues and the chemical composition of cellulose).

The number of generations formed by phytophagous mites during vegetation and the density of the local group (population) depend on the value of the Hydrothermal Index (HMI): the higher the average daily air temperature and the less precipitation, the greater the number of generations formed and the greater the population density on the leaf surface (Balyakina et al., 2021).

According to the data of the "Hydrometeorology and Monitoring Center" of the Ministry of Environment of RA, the years 2021 and 2022 were favorable for herbivorous mite growth and reproduction. In recent years, due to global climate change, a slight but continuous increase in air temperature has been observed. At the same time along with the increase in temperature, a decrease in atmospheric precipitation was observed (www.arm-monitoring.am). As a result, the years 2021 and 2022 were no exception, resulting in favorable conditions for mite reproduction and growth. Sometimes, the homogeneity of the average daily air temperature, the absence of sharp fluctuations, and the low amount of atmospheric precipitation during vegetation indirectly contributed to the formation of a large mite population in apple and plum orchards.

Star Crimson apple variety had a higher mite population index in both years of the study than Golden Delicious according to comparative analyses of apple and plum varieties. Similar results were observed with plums: the habitation data of the Vengerka Italian variety exceeded the indicators of the Vengerka Domestic and Victoria varieties.

The studies conducted in 2021-2022 also revealed the damage caused by phytophagous mites to different apple and plum varieties. The research findings confirm that in the case of apple trees (in 2021 and 2022), the Star Crimson variety was the most damaged by herbivorous mites, particularly the Hawthorn Red Spider Mite. Damage to the Golden Delicious variety was moderate.

In the case of plums (in 2021 and 2022), the highest rates of damage caused by the Common Spider Mite were recorded for the Vengerka Italian variety. Figures (1 and 2) present leaf mass damage data for the mentioned varieties (Star Crimson and Vengerka Italian) during the vegetation period.

The data presented in Figure 1 shows that the highest damage rates caused by the Hawthorn Red Spider Mite to the leaf mass of the Star Crimson apple variety were recorded between July 3-17, 2021-2022. Leaf damage peaked on July 3 in 2021 (43.5 %) and July 10 in 2022 (45.0 %).

In both years, the maximum damage indicators (peaks) differed by 7 days, primarily due to ecological and other factors.

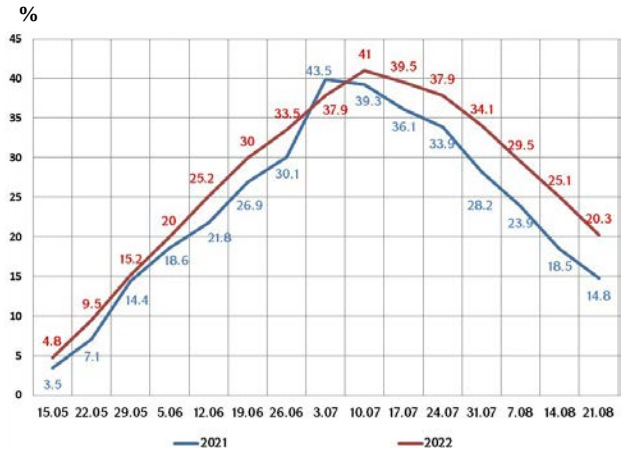

Figure 1. Damage of the hawthorn red spider mite to the Star Crimson variety by days of observation *(composed by the author).*

Among the three plum varieties observed in the two years of the experiments, the highest rates of damage by the Common Spider Mite were recorded on the Vengerka Italian variety (Fig. 2). The results of the observation confirm that the highest rates of leaf damage were recorded in July for both years of the experiments (on July 3, 2021- 39.9 %, on July 10, 2022 - 41.0 %). The leaf mass was relatively weakly damaged in the other apple and plum varieties.

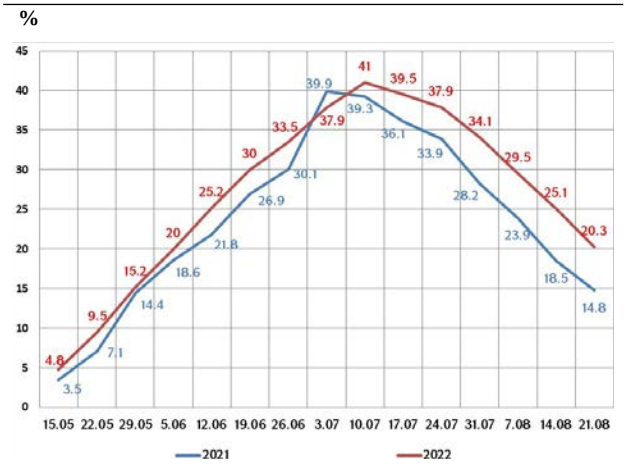

Figure 2. Damage of the Common Spider mite to the Vengerka Italian variety by days of observation *(composed by the author).*

Conclusion

The research findings indicate that, in 2021-2022, among the five studied apple and plum varieties, herbivorous mites (Hawthorn Red Spider Mite and Common Spider Mite) most strongly inhabited the Star Crimson apple and Vengerka Italian plum varieties. The Hawthorn Red Spider Mite habitation of the Star Crimson variety was 52.7 % in 2021 and 55.5 % in 2022. In the case of the Italian Vengerka variety, the indicators were 49.5 and 53.2 %, in 2021 and 2022 respectively.

Only two of the five studied varieties, the Star Crimson apple, and the Vengerka Italian plum, had the highest leaf damage rates. As a result, one variety of apple trees and one plum tree, most damaged by herbivorous ticks, were identified. Star Crimson apple varieties suffered the most damage during the peak in two years: 43.1 % in 2021 and 45.0 % in 2022. For plum trees, the Vengerka Italian variety suffered the most damage: the leaf mass damage during the peak was 39.9 % in 2021 and 41.0 % in 2022.

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Declarations of interest

The author declares no conflict of interest concerning the research, authorship, and/or publication of this article.

Accepted on 05.02.2024
Reviewed on 22.04.2024

AGRISCIENCE AND TECHNOLOGY
Armenian National Agrarian University
ԱԳՐՈԳԻՏՈՒԹՅՈՒՆ ԵՎ ՏԵԽՆՈԼՈԳԻԱ АГРОНАУКА И ТЕХНОЛОГИЯ
International Scientific Journal
ISSN 2579-2822

UDC 634.8:631.527 doi: 10.52276/25792822-2024.2-121

Rooting, Growth, and Maturation of Grape Cuttings Under Different Growth Regulators

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ARTICLE INFO

Keywords:
cutting,
grape,
growth regulator,
rooting,
Variety

ABSTRACT

With the development of viticulture in recent years, vineyard areas have increased and the demand for orchards with local varieties has grown. Propagation by cuttings is the most common method of grape propagation. The influence of growth regulators (zircon, heteroauxin, and kornevin) on the rooting, growth, and ripening of hardwood cuttings of grape varieties Voskehat, Garan Dmak, and Tozot was studied. The study shows that the use of growth regulators positively affects the growth and development of cuttings, strengthens roots, increases rooting, and promotes the growth and development of surface organs Among the regulators used, the best results were shown by growth stimulants heteroauxin and zircon. These stimulants can be used to ensure the high survival rates of less common varieties.

Introduction

With the development of viticulture in recent years, vineyard areas have increased and the demand for orchards with local varieties has grown. Propagation by cuttings is the most common method of grape propagation. Obtaining high-quality planting material requires rooting cuttings with a high percentage. Many factors affect rooting, such as polarity, quality, substances contained in the cutting, and growth regulator. Cuttings are propagated using auxins and artificial growth regulators (Ayvazyan, 2003; Grigoryan, 2001; Praveen Kumar Ausari, et al., 2023). There are currently many new-generation stimulants being investigated, including krezacin, zircon, and larixin (Maistrenko and Kologribaya, 2009; www.nest-m.ru).

Zircon is a natural Growth-Promoting Substance, that is nonhormonal, derived from the purple echinacea plant, and is harmless to plants. Its active ingredient, called hydroxycinnamic acid, is responsible for root growth and plant immunity enhancement (www.nest-m.ru). Kornevin and heteroauxin are also growth promoters, the active substance of Kornevin is indolyl butyric acid, and the basis of heteroauxin is indolyl acetic acid, which used to promote the rooting of cuttings. The treatment of grape cuttings with various growth regulators encourages both

the formation of a large number of roots and their continued growth in the soil (Turetskaya, 1949; Chailakhyan and Sarkisova, 1980; Grigoryan, et al., 2022). The study aims to investigate the effect of different rooting stimulants on native grape varieties that are less common.

Materials and methods

During 2022-2023, the experiments were conducted at Voskehat Viticulture Scientific Center's Nalbandian experimental station. Zircon, kornevin, and heteroauxin regulators were studied on the rooting of cuttings of Voskehat, Garan Dmak, and Tozot varieties. Technically, these cultivars mature late. For the experiments, 5-eye cuttings (30 cutting for each, with 3 repetitions) of Voskehat, Garan Dmak, and Tozot of local varieties were used. The experiments were conducted as follows: 1. The test water 2. Zircon 0.01 %, 3. krezacin 0.08 %, 4. Heteroauxin 0.02% growth regulators. Growth regulators were applied to the cuttings before clipping. The cuttings were immersed in the growth-regulating solution for 24 hours. Rooting was done with an electric root growth regulator. The duration of the incubation was 14-15 days. Rootstock growth, shoot growth, and root system development were studied at the vegetation's end. It determined the average length of shoots, woody roots, the number of rootlets and semi-main roots, and the root diameter (Lazarevsky, 1963; Rozhkov, et al., 2008). Statistical analysis was performed using the analysis of variance method (Mamajanyan, 2018).

Results and discussions

During the experiment, cutting adhesion, root number, root length, main root number, and root diameter were measured (Table 1). The data in the table show that the tested regulators had a regulating effect on the adhesion of the cuttings. The number of formed roots increased, but different varieties responded differently to the impact of the tested regulators. The heteroauxin regulator gave the highest adhesion results (90 %) for the Voskehat and Tozot varieties, and zircon gave the highest adhesion results (87.5 %) for the Garan Dmak variety. In the Voskehat variety, heteroauxin and zircon regulators showed effective results based on the number of formed and main roots. For the heteroauxin regulator, the measured indicators were 30 pieces, 5 pieces with 4.2 mm diameter, and for the zircon stimulator, 32 pieces, and 6 pieces with 5.3 mm diameter respectively.

Table 1. The effect of regulators on root adhesion, shoot growth, and development*

Growth regulators	Adhesion of cuttings, %	The number of formed roots, pieces	Root length, cm	Main roots	Diameter of main roots, mm
Voskehat					
Control	67	19	15.7	3.7	3.1
Heteroauxin	90	30	11.6	5	4.2
Kornevin	84.6	18.3	15.6	3.3	4.1
Zircon	79	32	14.7	6	5.3
Sx%=4.4 %, $LSD_{0.5}$=11.9 %					
Garan Dmak					
Control	52.9	19.3	15.1	3	3.1
Heteroauxin	62.2	21.3	12.3	5	4.5
Kornevin	68.4	24	10.3	3.7	3.5
Zircon	87.5	19.3	12.4	3.3	4.9
Sx%=8.8 %, $LSD_{0.5}$=17 %					
Tozot					
Control	42	14	9.5	4	3.8
Heteroauxin	90	22	8.8	5	4.3
Kornevin	88	19	10.9	4	2.8
Zircon	71	11	7	3	4.0
Sx%=6.5 %, $LSD_{0.5}$=16.3 %					

* Composed by the authors.

Table 2. Effects of Growth Regulator on shoot growth and maturation*

Growth-Promoting Substances	Number of shoots	Length of the shoots, cm	maturation of shoots, %
Voskehat			
Control	1.6	62.5	63
Zircon	2	66.4	66.8
Kornevin	2	51.2	63
Heteroauxin	2	53.3	68.3
Sx%=4.4 %, $LSD_{0.5}$=8.8 cm			
Garan Dmak			
Control	2	47.4	68.1
Zircon	2.6	49.2	81
Kornevin	2	41.2	68.3
Heteroauxin	2	40.2	75.3
Sx%=7.5%, $LSD_{0.5}$=10.5 cm			
Tozot			
Control	2	20	62.5
Zircon	2	20	65
Kornevin	2	30	60
Heteroauxin	2	45	67
Sx %=6.8 %, $LSD_{0.5}$=6.8 cm			

* Composed by the authors.

A different effect of the regulators was also observed on shoot and root length, and their maturation as shown in (Table 2). The Voskehat variety, by comparison with the control, showed the best result, with a shoot length of 66.4 cm and maturation of 66.8 %. Compared to zircon, in the case of heteroauxin regulator, shoots were shorter, but the percentage of maturation was higher (68.3 %). Garan Dmak variety treated with zircon also recorded an average shoot length of 49.2 cm and 81 % woodiness. Heteroauxin regulator resulted in a short shoot length, but a high percentage of maturation (75.3 %). The heteroauxin has shown effective results in the Tozot variety. The shoot length was 67 cm, and the maturation was 67 %. In the case of Zircon, the shoot length was 20 cm, but the maturation was high (65 %).

Conclusion

Considering the results of the study, we can conclude that the use of growth regulators for rooting cuttings is beneficial because it leads to a large number of roots being formed, increases cuttings adhesion, and contributes to normal shoot growth and lignification. Among the applied regulators, heteroauxin and zircon showed the best results. These can be used to ensure high adhesion of less common varieties.

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Declarations of interest

The authors declare no conflict of interest concerning the research, authorship, and/or publication of this article.

Accepted on 31.01.2024
Reviewed on 01.04.2024

AGRISCIENCE AND TECHNOLOGY
Armenian National Agrarian University
АГРОНАУКА И ТЕХНОЛОГИЯ
International Scientific Journal
ISSN 2579-2822

UDC 631.51.01(479.25) doi: 10.52276/25792822-2024.2-125

The Influence of Tillage Methods on the Agrophysical and Agrochemical Properties of Soils on the Example of Yernjatap Village

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ARTICLE INFO

Keywords:
agrophysical and agrochemical properties,
arable land,
degradation,
disking,
Tillage methods

ABSTRACT

The research was carried out in the administrative area of Yernjatap settlement, Aragatsotn marz, Aparan region, RA. This was at an altitude of 1850 m above sea level. Soil studies were conducted on about 1 hectare of arable land. The area is located in the steppe land zone. It was planned to investigate the shallow tillage (disking) in preventing degradation processes and increasing the efficiency of cultivated land in the investigated land area. For this purpose, field and laboratory analyses were carried out to study the soil quality characteristics. Soil sections were placed at the experimental sites. The percentage of humus content, mechanical composition, amount of water-soluble salts, soil reaction (pH), and provision of macronutrients in the soil samples were given according to the depth of each soil section. As a result of using traditional and shallow soil tillage methods, the agrophysical and agrochemical properties of the studied soils were revealed.

Introduction

Degradation of cultivated land has become a serious problem from the point of view of the ecological safety of human society and the biosphere. This threatens not only the reduction of total land areas but also decreases productivity of a unit of land (Avagyan, et al., 2020; Markosyan, et al., 2023; Markosyan, 2015).

The traditional method of soil cultivation is used in agriculture throughout the territory of RA. Traditional intensive agriculture requires powerful agricultural machinery with high productivity and huge energy and labor resources. Meanwhile, due to economic-ecological challenges in the modern world, agriculture requires updated and more effective approaches.

Literature confirms that soils undergo mechanization, lose their agrophysical properties, and become unstructured

under traditional cultivation. Therefore shallow tillage technology should be introduced and applied to traditional soil cultivation methods. The main and decisive link of this innovation is the cultivation of soil without turning. This is based on the principle of reducing the cultivated layer capacity and reducing the number of cultivations.

Based on international experience, minimal tillage technology restores properties lost due to intensive tillage in a relatively short period. At the same time, this technology contributes to increasing work productivity, efficiency, and the rational use of arable land. Minimal or shallow tillage of the soil provides an additional 30-50 mm of moisture accumulation and preservation. This protects the soil from wind and sun exposure during drought, and from water erosion and salinization in case of heavy rainfall and over-humidity (Adam, et al., 2023; Wang, et al., 2007; Teodor Rusu, et al., 2009).

This research revealed the influence of traditional and shallow cultivation methods on soil agrophysical properties and organic matter reserves. This was done on the arable lands of Yernjatap settlement, Aragatsotn region to determine the effectiveness of shallow tillage (disking) in preventing degradation processes and increasing soil efficiency. To clarify the mentioned issues, the results of field and laboratory research conducted in 2022-2023 in the arable lands of the Yernjatap settlement, Aparan region of the Aragatsotn marz were analyzed and compared.

Materials and methods

The test sites with a total area of 1 ha were located in the administrative area of the Yernjatap settlement of the Aragatsotn marz. It is located at an altitude of about 1850 meters above sea level at the southeastern foot of Aragats mountain, in the Aparan region, Aragatsotn marz, RA. The area's natural landscapes are black soils, where typical steppe vegetation grows. Agricultural land in the Yernjatap settlement is 1660.27 ha, of which the area of arable land for operational purposes is 583.00 ha (Yernjatap Community Development Plan (2017-2021) 2017; Soil Atlas of the Republic of Armenia (1990).

Cultivation of arable land here is carried out mainly by traditional tillage methods, which violate cultivation rules: longitudinal plowing of land on steep slopes, or deep plowing of land.

Based on this circumstance, to determine the effectiveness of cultivation methods in the arable lands of the settlement's administrative area, the method of disking was studied as an experimental option. Winter wheat cultivation methods were studied. The cultivation depth was 10-12 cm, and the conventional cultivation method with a depth of 20-22 cm was used as a control.

The size of each tillage variant tested was 225 m^2 (15m x 15m), and the experiments were set up with 3 replications (Table 1).

Soil sampling and preparation for analysis. Soil sampling and laboratory research were conducted to evaluate the impact of traditional and shallow tillage methods on agrophysical and agrochemical properties, as well as to determine the effectiveness of the implemented measures. According to the experimental sites, soil samples were collected from 0-20 cm and 20-40 cm depths, respectively, using a sampling auger.

The soil samples were taken to ANAU, an organic agriculture laboratory. The initial sample was mixed well, spread on a flat surface, divided into grids, and individual checkerboard grids were selected to obtain an average sample.

Crushed air-dried soil was sifted through a 2 mm sieve after being crushed in a glass sieve. An analytical sample was selected from the shredded average sample, and stored in labeled containers, to be used for further analysis.

Table 1. Scheme for field experiments*

I replication		**II replication**		**III replication**	
Conventional tillage 20-22 cm, (control)	Disking (10-12 cm)	Conventional tillage 20-22 cm, (control)	Disking (10-12 cm)	Conventional tillage 20-22 cm, (control)	Disking (10-12 cm)

*Composed by the authors.

To measure pH and electrical conductivity in soil samples, and to determine the amount of dissolved salts, a pH meter and an EC meter were used.

Also, humus content, mechanical composition, and easily hydrolyzable N content were determined by Turin and M. Kononova's method, the content of mobile by Machigin›s method, and the content of K by Maslova's method (Hayrapetyan, 2000; Farisyan, et al., 2020).

Results and discussions

It is evident from field studies, monitoring, and conversations with farmers that the majority of arable land in the settlement has been unused for a long time, resulting in some of it being trampled and turned into degraded, unstructured, and nutrient-deficient soils, especially adjacent areas.

The lack of irrigation water in the settlement makes it impossible to cultivate, which results in low profitability for agricultural holdings. The development of degradation in the area and the insufficient agrophysical and agrochemical properties of the land have also been contributed by the position and degree of slope. This has been contributed by surface flows, lack of flow buffer layers, non-use of soil protection sowing methods, constant operating winds, and of course traditional cultivation methods (Avagyan, et al., 2020).

Results of soil chemical analysis of the experimental area. Data on soil mechanical composition and humus content are given in Table 2. The taken soil samples were characterized as soils with a heavy clay-sand mechanical composition (the amount of physical clay was 47.9-56.1%) (Table 2).

However, in the disking version, the amount of physical clay is higher (by 2.4-7.1 %) compared to the control (up 20-22 cm), which is due to shallow cultivation, when the soil layer is turned over and does not mix with the lower layers, as well as the soil with a greater amount of plant residue on the surface. In the disking version, compared to the control (height 20-22 cm), there is an increase in the number of water-resistant aggregates by about 2.4-9.2 %.

The soil samples taken were characterized by medium (0-20 cm) humus availability, on which disking tillage, according to 2 years' data, did not have a significant impact (Table 2).

Figure presents the results of the soil water extract analysis. According to the sampling depths in the two experimental years, the soil samples analysed according to the cultivation methods have a similar pH, which is within the limits of neutral, and the amount of dissolved salts is low.

A comparison of the research results shows that disking as a shallow tillage method did not have a significant effect on soil pH, electrical conductivity, and the amount of dissolved salts (Figure). Data on macronutrient content in soil samples are given in Table 3.

Table 2. Humus content and mechanical composition of the investigated soil samples, 2022-2023*

Variants for field experiments	Depth, cm	Humus content, %		Physical clay content < 0.01mm, %		Water-resistant aggregates content > 0.25 mm, %	
		2022	2023	2022	2023	2022	2023
Conventional tillage 20-22 cm, (control)	0-10	4.06	4.06	48.2	47.9	44.1	43.9
	10-20	4.00	4.01	49.1	49.0	44.8	44.7
Disking (10-12 cm)	0-10	4.05	4.10	51.4	50.3	46.6	47.4
	10-20	4.03	4.11	55.9	56.1	51.3	53.9

*Composed by the authors.

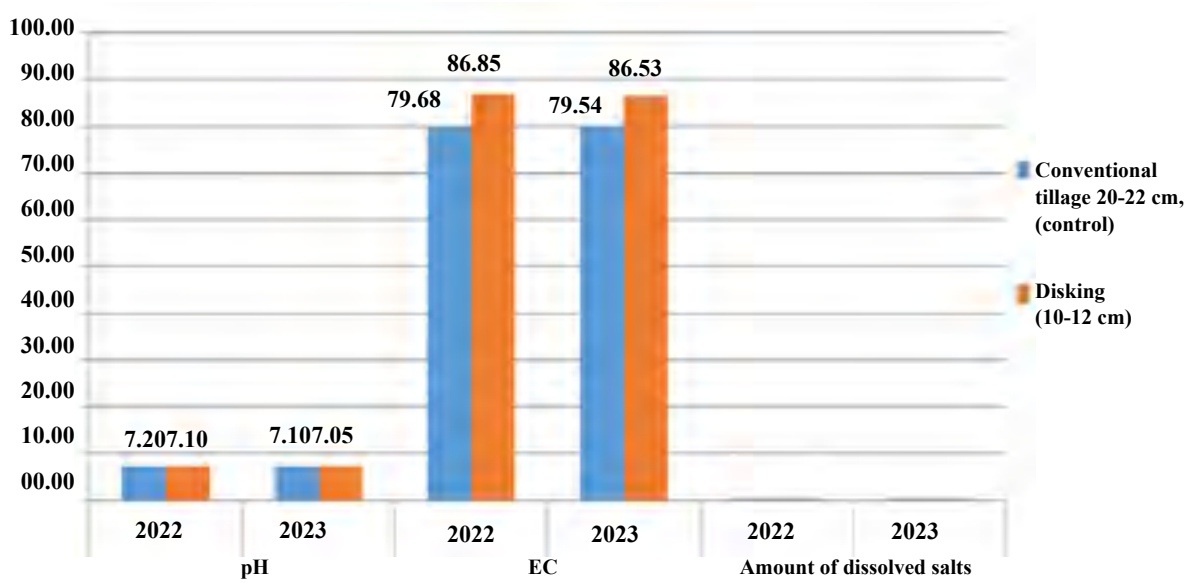

Figure. Results of the analysis of soil water extract.

Table 3. The results of mobile nutrients in soil samples (mg/100g of soil) according to the depth of the soil layer, 2022-2023*

Variants for field experiments	Depth, cm	*N*		P_2O_5		K_2O	
		2022	2023	2022	2023	2022	2023
Conventional tillage 20-22 cm, (control)	0-20	5.57	5.64	2.01	2.00	31.37	31.40
	20-40	4.18	4.00	2.00	1.98	28.55	28.63
Content according to norms, RA		Medium		Low		Medium	
Disking (10-12 cm)	0-20	5.71	6.08	2.72	3.81	36.78	42.51
	20-40	4.47	4.98	1.99	2.76	31.08	35.18
Content according to norms, RA		Medium and high		Low and medium		High and medium	

*Composed by the authors.

According to the norms adopted in RA, N is medium, K is medium, and P is low in soil samples from the control variant. In the case of disking, soil samples are provided with medium and high N, high and medium K, and low and medium with P.

There was a relatively higher accumulation of macronutrients in the root layers of the soil due to disking technology, shallow soil cultivation, and the presence of plant residues (Table 3).

Conclusion

Initial results from field and laboratory studies prove that the use of traditional cultivation technology in the arable land of the administrative area of Yernjatap settlement causes many negative phenomena: degradation of soil structural features, acceleration of the decomposition of organic matter and humus, destruction and dusting of the arable layer structure, loss of moisture and nitrogen, etc. Meanwhile, under shallow tillage, agrophysical and

agrochemical characteristics become favorable for the growth and development of field crops. This leads to the formation of a possible high yield.

Therefore, the modern agricultural system should focus not only on obtaining a properly planned harvest, but also on ensuring a balance between humus and mineral nutrients in the soil, environmental protection, and neutral soil degradation.

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Declarations of interest

The authors declare no conflict of interest concerning the research, authorship, and/or publication of this article.

Accepted on 01.04.2024
Reviewed on 06.05.2024

AGRISCIENCE AND TECHNOLOGY
Armenian National Agrarian University
АГРОНАУКА И ТЕХНОЛОГИЯ
International Scientific Journal
ISSN 2579-2822

UDC 631.812 doi: 10.52276/25792822-2024.2-130

Research on the Efficiency of Complex Fertilizer Produced from the New Serpentine-Based Ingredient

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ARTICLE INFO

Keywords:
fertilizers,
germination percentage,
germination rate,
plant growth,
serpentine,
soil fertility,
yield

ABSTRACT

Using serpentine, which is widespread in Armenia, we developed two new fertilizers. First fertilizer, is composed of phosphorus, calcium, magnesium, and sulfur, as well as amorphous silicon dioxide, and fertilizer 2, which contains a small amount of phosphorus (in the form of a mixture in the mineral), calcium, magnesium, sulfur, and amorphous silicon dioxide. Fertilizers were soluble in water and a 1 % ammonium carbonate solution. Laboratory studies have shown that fertilizers positively affect spring barley seed germination percentage, germination rate, growth, yield, and grain NPK content. The yield of spring barley increased by 28.4-33.1 % under the influence of fertilizers, which is equivalent to the efficiency of double superphosphate. However, serpentine, the most common in Armenia, can be used to obtain recommended fertilizers in a much cheaper and safer manner.

Introduction

The agricultural lands of the republic are known to be low in fertility. As a result, cultivated lands in RA have a low nitrogen supply of 100 %, a low phosphorus supply of 71-72 %, and a low potassium supply of 30-31 %. It has been proven by field experiments and by recording the harvest of many production crops that fertilizers are needed to increase crop production (Babayan, et al., 1990; Yeritsyan, et al., 2017; Ghazaryan, et al., 2022; Yagodina, 1989).

A majority of nitrogen fertilizers are imported from the Russian Federation, the Islamic Republic of Iran, the Republic of Georgia, and European countries, as mineral fertilizers have not been produced in RA since the 1990s. However, phosphorus is also important for RA, partly because potassium fertilizers are needed. There is also an importation of nitrogen-phosphorus-potassium complex fertilizers which are exclusively used in greenhouses and drip-irrigated gardens in the republic. In the republic, organic and biological fertilizers are produced in small

quantities, but they cannot completely replace mineral fertilizers. Due to the high prices of fertilizers, the majority of farmers in the republic cannot afford to purchase phosphorus and potassium fertilizers. Several studies have shown that fertilizers should also contain substances that indirectly contribute to plant growth as well as nutrients (Matychenkov and Lapushkin, 2023; Galstyan, et al., 2019) .This creates an opportunity to periodically reduce the amounts of nitrogen, phosphorous, and potassium fertilizers applied in the given area. It has been proven that these are mainly silicon-containing fertilizers (Bagarnikova, 2011; Silicon fertilizers, 2014; Rabinovich, 2020) also improve the physical and chemical properties of the soil (The mineral serpentine helps restore contaminated soils, 2022; Myazin, 1997; The use of serpentine in agriculture in the book Soil conditions and plant growth, 1955; Shveikina, et al., 1999; Farsian, et al., 2020).

It is important to note that one of the indirect benefits of such fertilizers is the reduction in water consumption during harvest (Silicon Fertilizers, 2014; Kulikova, et al., 2007). This makes it possible to obtain an economically justified harvest from grain and fodder crops in the arid agricultural areas of the Republic of Armenia. In addition to mitigating the development of plant diseases (such as blackleg and black leg), these fertilizers also reduce pest development (such as the Colorado potato beetle, and tick) thus reducing pesticide use (Aleshin, et al., 1986; Ammosova, et al., 1990; Matychenkov, et al., 2016 and 2022; Pashkevich, et al., 2008).

Taking into account the above, the Institute of General and Inorganic Chemistry Named After Academician Manvelyan State Non-Profit Organization and the Scientific Center of Soil Science, Agrochemistry and Reclamation named after H. Petrosyan of the ANAU, have been working in recent years to develop a technology to obtain complex fertilizers of a new composition based on serpentines, which are widespread in the Republic of Armenia, including containing phosphorus, calcium, magnesium, sulfur, amorphous silicon dioxide and containing calcium, magnesium, sulfur, amorphous silicon dioxide. It should be noted that the technologies for obtaining these waste materials are extremely simple, environmentally safe, and less expensive.

Materials and methods

An important scientific novelty is to observe the results of serpentine-based fertilizers obtained by the research group in laboratory and vegetation experiments: “fertilizer 1” (phosphorus, calcium, magnesium, sulfur, amorphous silicon dioxide) and “fertilizer 2” (calcium, magnesium, sulfur, amorphous silicon dioxide) agrochemical properties: solubility in distilled water and a 1 % solution of ammonium carbonate, including successively affecting the same weight with the specified solutions.

The effects of these fertilizers on spring barley seed germination, germination rate, and shoot and embryonic root growth were determined in laboratory and vegetation studies as follows:

- Germination percentage and germination rate of spring barley seeds in a field.
- Concerning the weight and growth of plants’ above-ground mass and root system.
- The main nutrients in the ground-mass and root system during rooting.
- Grain yield and chemical composition.
- Content and absorption capacity of mobile nutrients (NPK) in the soil.

Double superphosphate was used as a standard fertilizer containing phosphorus.

The following scheme was used to determine seed germination and germination energy in laboratory conditions (Victorov, 1969):

1. Without fertilizer (water, checker)
2. Serpentine+H_3PO_4 (soaking of seeds)
3. Serpentine+H_2SO_4 (soaking of seeds)
4. Double superphosphate (seed soaking, standard)

On the 19th kilometer of the Yerevan-Hrazdan road, near the arable land on the left side of the road, where autumn wheat was sown, four repetitions of dark brown soil were used for vegetation experiments. The vegetation vessel can hold 6 kg of soil. Plants and soil were analyzed chemically using the methods accepted in RA (Mineev, 2001). Experiments were conducted according to the following scheme.

1. Without fertilizer (check)
2. $N_{0.2}K_{0.1}$ (background)
3. Background + $P_{0.2}$ fertilizer 1
4. Background + $P_{0.2}$ fertilizer 2
5. Background + $P_{0.2}$ double superphosphate (standard)

Where, 0.1 means 0.1 g of active substance for 1 kg of soil, 0.2 means 0.2 g of active substance for 1 kg of soil.

During the vegetation period, observations and counts were made. We measured seed germination, germination

energy, plant height at tuber and maturity stages, above-ground mass, and root mass weight of 10 plants. Nitrogen, phosphorus, and potassium were determined in the above-ground mass and roots of the plants. In this process, the weight was burned in sulfuric acid, then nitrogen content was determined by distillation, phosphorus by colorimetry, and potassium by flame photometry (Mineev, 2001). Using the dispersion analysis method (Khachatryan, 2002), harvest data were mathematically processed.

The soil was characterized by humus content using Turin, mechanical composition using Kaczynski, pH using a pH meter, and carbonates using a calcimeter. A complexometric method was used to determine the amount of soluble calcium and magnesium in water. The amount of nitrogen available to plants was determined by Tyurin-Kononova, phosphorus by Machigin, and potassium by Machigin solution (Mineev, 2001).

Results and discussions

Knowing the agrochemical characteristics of the soil in advance is crucial to planning the fertilization of crops effectively. Based on this information, fertilizers can be applied scientifically. In this case, it is important to design the experiment scheme correctly, particularly when determining the effectiveness of new composition fertilizers. To reduce costs, such studies typically begin with laboratory and vegetative experiments, which allow daily control of the growth and development of plants.

As for the soil used for the vegetation experiments, it had a powdery structure, hardened when dried, and had a loamy mechanical composition. This is because crop rotation is not carried out in this area, and organic fertilizers are not applied. At the same time, such a situation is currently characteristic of a significant part of the cultivated land areas of the republic (Babayan, et al., 1990; Soil Atlas of the Republic of Armenia, 1990).

According to the agrochemical analysis of the soil selected for vegetation experiments (Table 1), the humus content was 2.59 %, the reaction was weakly basic, and calcium was 1.38 times greater in the aqueous solution than magnesium. The experiment scheme was developed based on these data.

An important property of fertilizers is their solubility in water and in solvents used to determine soil mobile nutrients (phosphorus, potassium). The results of the studies carried out in laboratory conditions (Table 2) revealed that when the fertilizers with the mentioned solvents were first treated with distilled water, 3.86 % of fertilizer 1, passed into a solution with the following composition mg/% phosphorus (1400), potassium (8.64), calcium (560), magnesium (1520), sodium (25.7).

Meanwhile, 23.41 % solution passed from fertilizer 2, where phosphorus (in the form of a mixture in the mineral) was only 250 mg, potassium was 8.64 mg, calcium was 800 mg, magnesium was 10880 mg, and sodium was 25.76 mg in 100g of fertilizer. It should be added that the main substance dissolved in fertilizer 2 was amorphous silicon dioxide, which was well-soluble in acid.

The same weight of fertilizer treated with distilled water for a second time leaches more phosphorus from fertilizer 1. In contrast, the amount of soluble substances in fertilizer 2 decreased dramatically because phosphorus was lacking in fertilizer 2. There was also a decrease in calcium and magnesium dissolved in the water.

When fertilizers were treated with ammonium carbonate solution for the first time, the amount of phosphorus came out the same as when it was treated with water, and the amount of other nutrients did not change significantly. The amount of phosphorus decreased significantly after the second treatment, while the other nutrients remained virtually unchanged.

Accordingly, 1 % aqueous and ammonium carbonate solutions passed the majority of phosphorus from the recommended fertilizers. In addition to being essential and irreplaceable nutrients, these nutrients were also used by plants.

Table 1. Agrochemical characteristics of soil taken for vegetation experiments*

Soil type, sampling depth, cm	Humus, %	Mechanical composition, physical clay, %	pH	Carbonate content, %	Dissolved in water mg/eq in 100 g soil		The content of nutrients available to plants in (mg), in 100 g soil		
					Ca	*Mg*	*N*	*P_2O5*	*K_2O*
Dark brown 0-30 sm	2.56	47.4	8.1	3.5	1.8	1.3	3.7	1.45	47.61

*Composed by the authors.

Table 2. Solubility of serpentine-based fertilizers in distilled water and 1% ammonium carbonate solution*

Options	pH	Substances dissolved in water, %	mg in 100 g of fertilizer				
			P_2O_5	K_2O	Ca	Mg	Na
Solubility in water at 1st exposure							
Serpentine+ H_3PO_4 (Fertilizer 1)	7.9	3.86	1400	8.64	560	1520	25.76
Serpentine +H_2SO_4 (Fertilizer 2)	4.5	23.41	250	8.64	800	1088	25.76
Solubility in water at 2nd exposure							
Serpentine+ H_3PO_4 (Fertilizer 1)	7.9	5.15	1714	8.61	1280	1440	12.27
Serpentine +H_2SO_4 (Fertilizer 2)	7.0	2.30	5	8.63	680	840	9.20
Solubility in $(NH_4)_2CO_3$ at 1st exposure							
Serpentine+ H_3PO_4 (Fertilizer 1)	-	-	1400	8.64	800	720	25.74
Serpentine +H_2SO_4 (Fertilizer 2)	-	-	250	8.60720	560	712	25.72
Solubility in $(NH_4)_2CO_3$ at 2nd exposure							
Serpentine+ H_3PO_4 (Fertilizer 1)	-	-	96	8.51	560	710	24.53
Serpentine +H_2SO_4 (Fertilizer 2)	-	-	76	8.53	480	705	8.00

Table 3. Effects of Serpentine-Based Fertilizers on Laboratory and Field Germination percentage, Germination Rate, and Seedling Growth of Spring Barley Seeds*

Options	Under laboratory conditions					Under vegetative conditions	
	Germination, %	Germination rate, %	The weight of the embryonic roots of 10 seedlings, g	Root weight, g	Number of roots per seed	Germination, %	Germination rate, %
1	91.6	76.4	0.28	0.061	6.1	86.5	71.3
2	95.4	84.3	0.33	0.079	6.4	90.9	81.2
3	95.9	85.8	0.35	0.084	6.8	92.9	83.0
4	91.7	76.7	0.30	0.065	6.1	86.9	71.7

Options: *1. No fertilizer (water/control), 2. Serpentine+ H_3PO_4 (seed soaking), 3. Serpentine+ H_3PO_4 (seed soaking), 4. Double superphosphate (seed soaking).*

*Composed by the authors.

It was completely favorable for crops to grow in aqueous solutions of fertilizers, except crops growing in soils with an acid reaction (Table 2).

It was found that soaking spring barley seeds in a 0.1 % solution of fertilizer before sowing increased germination percentage, and germination rate, primarily due to the indirect effect of fertilizers, including the significant amount of amorphous silicon dioxide present in fertilizers, and promoted increased seed germination and germination energy (Table 3).

The results were in line with the findings of (Ammosova, et al., 1990; Vlasenko, 2019; Application of serpentine in agriculture, 1955; Slukovskaya, 1922). Thus, under the influence of the studied fertilizers (versions 2, 3), seed germination increased by 4.1-4.7 %, and the rate

of germination increased by 10.3-12.3 % compared to the control. In vegetation experiments, germination parameters changed similarly under the influence of these fertilizers (Table 3).

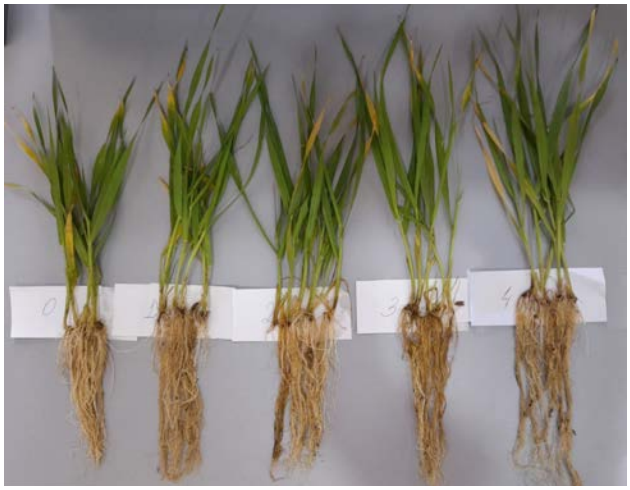
Meanwhile, in laboratory conditions, germination parameters under double superphosphate had almost no change. In both laboratory and vegetative experiments, the recommended fertilizers increase the number of sprouts and embryonic roots. Table (3) shows that serpentine plus H_2SO_4 has a slightly higher effect.

In vegetative experiments, fertilizer effects on spring barley growth are also preserved in later stages of plant development, such as stemming (Pic., Table 4).

According to the tester, at this stage of plant growth, under the influence of fertilizers of the new composition (options 2, 3), plants increased by 10.2-16.0 % in mass, root mass weight increased by 12.3-13.6 %, stem height increased by 14-16.7 %, and leaf number increased by 3.8-5.1 %. Superphosphate also has a positive effect, but it is partially inferior to recommended fertilizers. A fertilizer effect on the above-ground mass and root system content of NPK was also observed at the above-mentioned stage of plant growth and development (Table 5).

According to the table, the content of the specified nutrients in the plant's dry mass depends on the fertilization option.

Thus, nitrogen, phosphorus, and potassium content in the groundmass and root system of the plant increased when the recommended fertilizers were applied. Even though these fertilizers do not contain nitrogen, they are still effective. It is because they contain amorphous silicon dioxide, which helps the soil absorb NPK more effectively (Bagarnikova, et al., 2011; Report, 2020).



Picture. The effect of serpentine-based fertilizers on spring barley sprout growth.

When phosphorus-containing fertilizers were applied (options 2, 4), the phosphorus content in the plant's above-ground mass increased dramatically, indicating that the plants had access to it. The root system of the plant showed a similar pattern. NPK amounts in the roots increased due to the recommended fertilizers.

Table 4. The effect of serpentine-based fertilizers on spring barley sprout growth*

N	Options	Seedling dry weight, in 10 seedlings, g	Compared to the checker, %	Root dry weight, g	Compared to the checker, %	Seedling length, cm	Compared to the checker, %	The number of leaves per seedling
1	No Fertilization (Checker)	2.25	-	0.81	-	15.0	-	7.8
2	Serpentine+H_3PO_4 (Fertilizer 1)	2.48	10.2	0.91	12.3	17.1	14.0	8.1
3	Serpentine +H_2SO_4 (Fertilizer 1)	2.61	16.0	0.92	13.6	17.5	16.7	8.2
4	$Ca(H_2PO_4)_2H_2O$ (standard)	2.41	7.1	0.87	7.4	17.1	14.0	8.1

*Composed by the authors.

Table 5. Effect of fertilizers applied to the base of serpentines on the above-ground mass and root system of spring barley at the 7-8 leaf stage (dry mass) *

N	Options	Above ground biomass, %			Root mass, %		
		N	***P_2O_5***	***K_2O***	***N***	***P_2O_5***	***K_2O***
1	No Fertilization (Checker)	2.45	0.18	0.68	2.06	0.14	0.51
2	Serpentine +H_3PO_4	2.61	0.30	0.77	2.18	0.26	0.58
3	Serpentine +H_2SO_4	2.58	0.21	0.79	2.21	0.19	0.59
4	$Ca(H_2PO_4)_2H_2O$ (standard)	2.49	0.28	0.67	2.07	0.27	0.50

Table 6. Effect of serpentine-based fertilizer on yield of spring barley under vegetative conditions*

Options	Plant height, sm	Number of grains per spike	Grain yield, g/pot	Yield increase		Content per grain, %		
				g/pot	%	***N***	***P_2O_5***	***K_2O***
1	39.1	15.4	6.62	-	-	1.79	0.57	0.51
2	42.4	17.8	7.15	0.53	8.0	2.10	0.48	0.67
3	44.3	19.3	8.50	1.88	28.4	2.36	0.86	0.69
4	44.5	20.3	8.81	2.19	33.1	2.39	0.85	0.68
5	43.4	19.4	8.69	2.07	31.3	2.31	0.78	0.65
	$LSD_{0.95}$	0.49		Sx%	1.38			

Options: *Options 1. No fertilizer (control), 2. N_2K_2 (background), 3. Background+P_2 serpentine+ H_3PO_4, 4. Background+P_2 serpentine+ H_3PO_4, 5. Background+P_2 double superphosphate.*

*Composed by the authors.

A fertilizer's effectiveness in enhancing crop growth yield and crop quality indicators must be determined before it can be recommended for production. Thus far, only vegetative experiments have been conducted on proposed fertilizers.

Using the recommended fertilizers (table 6), the results showed that both the yield of spring barley and its content of essential nutrients increased, as evidenced by the results in the version without fertilizer and the version receiving double superphosphate fertilizer.

Conclusion

Results of the experiments indicate that serpentine-based complex fertilizers gradually dissolve in water, so they have a long-lasting effect. Fertilizers also contain amorphous silicon dioxide, which gives them indirect benefits, including improving the germination of seeds in the lab and the field, increasing mobile nutrients in the soil, and increasing yields. To fully discover the effectiveness of fertilizers and to invest in production, field, and production experiments in different soil zones of RA, in wet and dry conditions, will be required to evaluate the effectiveness of fertilizers obtained by researchers in comparison with superphosphates.

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Declarations of interest

The authors declare no conflict of interest concerning the research, authorship, and/or publication of this article.

Accepted on 19.04.2024
Reviewed on 06.05.2024

AGRISCIENCE AND TECHNOLOGY
Armenian National Agrarian University
ԱԳՐՈԳԻՏՈՒԹՅՈՒՆ ԵՎ ՏԵԽՆՈԼՈԳԻԱ АГРОНАУКА И ТЕХНОЛОГИЯ
International Scientific Journal
ISSN 2579-2822

UDC 6371.047 doi: 10.52276/25792822-2024.2-138

Biochemical Indicators of Blood and Milk in the Cows Affected by Latent Mastitis

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ARTICLE INFO

Keywords:
biochemistry,
blood,
cow,
mastitis,
milk

ABSTRACT

Latent mastitis harms the health of animals, their milk production, and the quality of milk. In cows affected by this disease sharp changes in hematological parameters, and biochemical parameters of blood and milk, which is the focus of our research. This work studies the morphological and biochemical parameters of blood and the biochemical parameters of milk in dairy cows affected by latent mastitis. The research was performed in several farms and farm households of Kotayk and Ararat regions, as well as in the ANAU Research Center of Veterinary Medicine and Veterinary Sanitary laboratories. The research outcomes prove that latent mastitis significantly impacts the composition of blood and milk components. Data obtained during the research enables a better understanding of the causes of mastitis as well as the necessity of using informative diagnostic methods in farm veterinarians' practices.

Introduction

Subclinical mastitis is a common disease insidiously developing in cow udders which causes considerable damage to the dairy industry. Mastitis entails an increase in infertility rate, raises the rate of culling and medical treatment costs of livestock, and causes a 10 to 15 percent decrease in milk yield in cows so that the underproduction of milk throughout the lactation period amounts to 500-700 liters of milk per dairy cow, on average (Radionov et al., 2011; Velikanov et al., 2021).

Mastitis milk has altered biochemical composition as well as deteriorated technological properties; it has transformed the concentration of somatic cells in the milk, changed the rate of proteins and lactose, and decreased the content of free fatty acids (Andreev, 2019; Sidorova et al., 2020). Therefore, the presence of mastitis milk in feedstock milk is undesirable (Yefimova et al., 2019). Veterinary experts need to understand the processes running on in the malfunctioning lacteous glands since modern treatment regimens are impossible without such understanding (Momsikova et al., 2017; Cherenok, 2020).

Materials and methods

Both clinically healthy cows and cows with latent mastitis were studied and compared for their hematological and biochemical parameters of blood and milk. The research was performed regarding lactating pluripara cows of the Brown Caucasian and Jersey breeds, aged 5 to 6 years, that were not impaired by post-parturient complications. The animals were kept in stalls and pastures, and their diet consisted of concentrated roughage feed and root crops. The research was carried out in certain farms and farm households of the Kotayk and Ararat regions. In addition, it was carried out in the Laboratory of Veterinary Medicine and Veterinary Sanitary Expertise.

Tested materials included whole raw cow's milk and blood taken from healthy animals and animals affected by latent mastitis. 60 cows were tested during the experiment, and 14 animals were affected by latent mastitis (23.3 %). Based on the analogy, 11 animals were selected from healthy cattle and a reference group. 11 cows were affected by latent mastitis to form an experimental group. All animals were kept under similar conditions.

By hand milking, milk samples were collected from the experimental and reference groups, in the amount of 50 ml from each quarter of the udder. They were promptly delivered to the laboratory for biochemical testing. The fore milk was disposed of, while the rest was tested. To detect latent mastitis, the California Mastitis Test was used, which allows a rapid count of somatic cells in milk.

The high sensitivity of this test is given by tracking two factors at once - the viscosity and color intensity of the samples (Polyantsev, 2015). To increase the reliability of subclinical mastitis detection, milk sedimentation tests were performed in the following way. Whenever a California Mastitis Test result was positive, 10-15 ml of milk was poured into test tubes from each udder quarter. After milking, the milk was placed in the refrigerator for 16-18 hours, and the response was checked one day later.

In the case of milk taken from cows affected by mastitis, sediment appeared at the bottom of the test tube. The sediment height was measured. The cow was considered to have mastitis if the sediment height exceeded 0.1 cm. Biometrical processing was performed on a computer using Microsoft Office Excel software. The values of obtained data were presented in M ± m format, where M is for a mean value, and m is for a standard error of the mean (Grachev, 2012).

For morphological and biochemical analyses, blood samples were taken from cows' jugular vein early in the morning. The morphological composition of blood was examined by use of a MicroCC-20 plus analyzer, total protein was determined by refractometry method, the total calcium content in blood serum – by the method of Karakashov and Vichev, and immunoglobulin content – by the method of enzyme immunoassay.

Results and Discussions

As Table 1 shows, 46 animals (76.6 %) from among 60 tested ones had a negative response to the mastitis test, 6 animals (10 %) gave a positive response, and 8 animals (13.3 %) gave an explicit positive response.

According to Table 2, blood protein composition changes in cases of latent inflammation and mastitis in cow udders. The total protein content (total amount of all circulating proteins) in the experimental group had decreased in comparison with the reference group from 85.7±0.3 g/l to 62.3±0.7 g/l, i.e., by 23.4 g/l on average and by 5.7 g/l compared to the standard values.

Table 1. Response to mastitis test in the examined animals*

Test Response	Number of Animals, unit	Body Cell Count, thous/cm^3	Ratio, %
Negative	46	100 - 300	76.6
Positive	6	300 - 500	10
Explicit Positive	8	over 500	13.3

*Composed by the authors.

Table 2. Hematological and biochemical parameters of blood in clinically healthy cows and the cows affected by latent mastitis*

Parameter	Unit of measurement	Standard Values	Reference Group (n=11)	Experimental Group (n=11)
Erythrocytes	1012/ l	5 – 7.5	5.63 ± 0.3	5.76 ± 0.2
Hemoglobin	%	90 – 120	98.6 ± 0.4	97.3 ± 0.6
Leukocytes	g/l	4.5 – 12	8.1 ± 0.6	3.2 ± 0.5
Total protein	g/l	68 – 87	85.7 ± 0.3	62.3 ± 0.7
Immunoglobulins	g/l	29 – 49	28.6 ± 0.8	15.1 ± 0.2
Total calcium	mmol/l	2.1 – 2.8	2.54 ± 0.03	1.5 ± 0.02

Table 3. Biochemical parameters of milk in the healthy cows and the cows affected by latent mastitis*

Indicator	Unit	Standard	Reference group (n=7)	Experimental group (n=7)
Mass Fraction of Fat	%	3.8	3.4	3.0
Mass Fraction of Protein	%	3.3	3.2	2.6
Density	kg/m^3	27 - 33	28.93 ± 0.04	27.84 ± 0.09
Acidity	^0T	16 - 18	16.71 ± 0.06	20.32 ± 0.04
Somatic cells	$thous/cm^3$	up to 200.000	237.22 ± 1.24	436.23 ± 1.22

*Composed by the authors.

Picture. Alteration of texture and color in the mastitis milk.

Besides, the immunoglobulin content of blood had decreased in the affected animals from 28.6±0.8 to 15.1±0.2 g/l, because of being consumed for immune response and combat with the pathogenic microbes causing inflammation in the affected udder. The average difference in this parameter between the reference and experimental groups was 12.9 g/l. The average difference between the experimental group and the standard value was 13.9 g/l.

A decrease in the number of leukocytes in the reference group was detected compared to the experimental group, from 8.1±0.6 to 3.2±0.5 g/l, reflecting the transfer of leukocytes into the affected mammary gland for phagocytosis. The average difference in this parameter between the reference and experimental groups was 4.9 g/l. In contrast, the average difference between the experimental group and the standard value was 1.3 g/l.

Moreover, the blood of animals in the experimental group had a lower rate of total calcium 1.5±0.02 mmol/l compared to 2.54±0.03 mmol/l in animals in the reference group. The difference in this parameter between the reference and experimental groups was 1.4 mmol/l, while

the average difference was 0.6 mmol/l by 0.11 mmol/g. About 10 g of calcium circulates in the cow blood, and there is a large reserve of this microelement (6000 g) in the cow bones as well. After calving, calcium is eliminated from the cow's body with every milking. On the other hand, the animal cannot extract calcium from its bone reserves or food; which leads to decreased calcium rate in the blood (Zimnikov et al., 2020). In addition, there was an alteration in some biochemical parameters when testing the milk (Table 3).

The milk tests revealed that in the cows affected by subclinical mastitis (experimental group), certain biochemical parameters of milk are altered in comparison with the clinically healthy animals (reference group) because the ability of secretory cells to synthesize the main components of milk influences the inflammation of mammary glands. As follows from Table 3, the density of standard milk (ratio of milk mass at 20 ^{0}C to the mass of the same quantity of water at 4 ^{0}C) ranges from 27 to 33 kg/m^3, however, in the experimental group of animals, it decreased by 1.09 kg/m^3 compared to the reference group. The acidity of milk in the experimental group animals had increased by 6.61°T compared to the reference group.

This is caused by the acidic compounds in milk, such as citric, lactic, carbonic, ascorbic, and fatty acids.

The standard mass fraction of fat is 3.8%, but it decreased in the experimental group compared to the reference group, from 3.6% to 3.0%. At the same time, the mass fraction of protein decreased as well, from 3.6% to 30%.

Healthy milk contains somatic cells, at a rate of up to 200 thous/cm3. However, the tests revealed that, in the case of latent mastitis, the somatic cell content of milk in the animals of the experimental group had reached up to 436.23±1.22 thous/cm3, which is an indication of subclinical mastitis and the need for timely treatment of the affected animals (Stepanova et al. 2019).

Conclusion

Research proves that latent mastitis affects the hematological and biochemical parameters of blood (a decrease in the number of leukocytes and a decrease in the content of total protein, immunoglobulins, and total calcium).

Latent mastitis changes milk biochemical parameters, it increases milk acidity and decreases the ratio of protein to fat, reducing its nutritional value and suitability for further processing. The altered component ratio in milk negatively affects its organoleptic properties. When milk is contaminated with mastitis, it becomes salty and bitter to the taste. It creates unfavorable conditions for dairy milk processing into fermented milk products.Regular analysis of the hematological and biochemical parameters of blood and the biochemical parameters of milk can be a valuable diagnostic aid for monitoring animal health, so it shall be widely used by farm veterinarians wherever possible.

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Declarations of interest

The authors declare no conflict of interest concerning the research, authorship, and/or publication of this article.

Accepted on 29.02.2024
Reviewed on 22.04.2024

AGRISCIENCE AND TECHNOLOGY
Armenian National Agrarian University
ԱԳՐՈԳԻՏՈՒԹՅՈՒՆ ԵՎ ՏԵԽՆՈԼՈԳԻԱ АГРОНАУКА И ТЕХНОЛОГИЯ
International Scientific Journal
ISSN 2579-2822

UDC 619:636:612.36 doi: 10.52276/25792822-2024.2-143

A Prooxidant and an Antioxidant Sow's Status with Hepathopathy

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ARTICLE INFO

Keywords:
antioxidant protection,
blood,
hepatopathy
lipid peroxidation,
sows

ABSTRACT

The role of lipid peroxidation in the pathogenesis of liver diseases in sows was studied. The state of the antioxidant system in these diseases was also assessed. The liver of sows has been examined after slaughter. There were four groups formed: healthy, acute and chronic hepatosis (HS), and liver cirrhosis. An increase in the level of endogenous intoxication has established, the content of primary (diene conjugates), secondary (malondialdehyde, ketodienes, ketotrienes), and final (Schiff base) products of lipid peroxidation in the blood of sows with hepatopathy. Also noticed that sows with hepatopathy had decreased antioxidant protection, catalase activity, and concentration of tocopherol and ascorbic acid. The level of change was growing with a gravity of hepatopathy. The most expressed disturbance has been observed in sows with liver cirrhosis.

Introduction

In animal and human cells, reactive oxygen species (free radicals) are constantly formed. Free radicals are highly reactive and easily change from one form to another, oxidizing various molecules. Polyunsaturated fats (PUFAs) with a large number of unsaturated bonds in their carbon are especially sensitive to oxidation (Vladimirov, 2000, Lyahovich,et al., 2005). With an excess of reactive oxygen species, a cascade of reactions occurs in the destruction of PUFAs and the formation of new free radicals. This process is called lipid peroxidation (LPO). Control throughout oxidative reactions in the body and their timely termination is carried out by the antioxidant system (AOS). This system is represented by enzymatic (catalase, superoxide dismutase, glutathione peroxidase, ceruloplasmin) and non-enzymatic (vitamins E and C, glutathione, and others) parts (Ore and Akinloye., 2019, Abramov, et al., 2007). Uncontrolled LPO is the cause of destabilization and disruption of barrier, transport, receptor, and other functions of biological membranes, breaking of DNA strands, oxidation of proteins, etc. (Boldyreva, et al., 2021).

It is known that the imbalance between LPO and AOS is an important component of the pathogenesis of many internal diseases, in particular liver diseases (Ore and Akinloye, 2019, Plieva, et al., 2023, Bulatova, et al., 2014). This imbalance is accompanied by the development of endogenous intoxication in patients, provoking the progression of pathological processes (Krutikova, et al., 2022).

At the same time, a relatively small number of scientific works are devoted to the study of the state of LPO and AOS in pigs. In particular, the positive effect of high antioxidant status on the growth performance of piglets (Balogh, et al., 2012), an increase in LPO and inhibition of AOS during malnutrition in piglets (Piatrousky, et al., 2010), and normalization of the imbalance between LPO and AOS when using microelements in growing piglets has been determined (Vorobiev, et al., 2015). The problem of the state of LPO and AOS in weaned piglets with toxic hepatodystrophy is the subject of research by V.V. Velikanov. The authors established an increase in LPO products in the blood of sick animals with simultaneous inhibition of their antioxidant status (Velikanov, 2017).

Thus, information on assessing the state of LPO, and AOS in sows with liver pathologies (hepatopathies) of varying severity is not presented in the available literature. Meanwhile, these diseases (primarily toxic hepatosis with an acute and chronic course) in sows in industrial pig farming are significantly common (Piatrouski, et al., 2023). In this regard, the goal of our work was to determine the states of LPO, AOS and endogenous intoxication in sows during the development of hepatopathy.

Materials and methods

In the conditions of swine breeding complexes, after the planned and forced slaughter of the main sows, an inspection of the liver was carried out. Based on the examination, four groups of animals were formed: the first - conditionally healthy sows without macroscopic changes characterizing hepatopathy (n=23), the second - sows with signs of acute HS (n=10), the third - sows with signs of chronic HS (n=10)), fourth – sows with liver cirrhosis symptoms (n=8). The results of macroscopic studies were subsequently confirmed by histological studies (Piatrouski, et al., 2023). Before slaughter, two groups of blood samples were collected from all sows: with heparin (to obtain plasma and hemolysate) and without heparin (to obtain serum). The content of diene conjugates (DC), ketodienes and conjugated ketotrienes (KD and CKT), Schiff bases (SBs), ascorbic acid (ASC), total tocopherol (TT), substances with medium and low molecular weight (MLMWS) were determined in the blood plasma, in the hemolysate - the concentration of malondialdehyde and other products that react with thiobarbituric acid (TBA) (MDA) and catalase activity, in the serum - antioxidant activity (AOA) and the level of a several biochemical blood parameters (Piatrouski and Kotovich, 2023).

The oxidative status of animals was assessed by the content of DC, KD and KT, SBs (Volchegorsky, et al., 1989, Lvovskaya, et al., 1991), MDA (in reaction with thiobarbituric acid) (Abramov, et al., 2007). The enzymatic link of antioxidant status was assessed by the levels of catalase activity (Kondrakhin, et al., 2004, Góth, 1991), non-enzymatic - at the levels of concentrations of TT (Kholod and Ermolaev, 1988), and ASC (Kholod and Ermolaev, 1988). In general, antioxidant status in the blood was determined by the level of AOA (Erel, 2004), and the degree of endogenous intoxication was determined by the level of MLMWS.

The content of DC, KD+KT, andSBs was determined in heptane–isopropanol fractions, since mainly neutral lipids (including triglycerides) are extracted in heptane (n-C7) and phospholipids are extracted in isopropanol (IPA).

Digital material was subjected to statistical processing. The tables present group averages (X), standard deviations (σ), and statistical significance of the nonparametric Mann-Whitney test (U) for differences between group indicators (p). The results were considered statistically significant based on a significance level of 0.05.

Results and discussions

Our studies have shown that the content in the blood of sows of both primary (DC) and secondary (KD and KT, MDA), and final (SBs) lipid peroxidation products were significantly lower in healthy animals (Table 1).

The research results indicate that the content of primary and secondary lipid peroxidation products in the blood plasma of sows with liver pathologies was statistically significantly higher than that of sows of the first group.

In both heptane and isopropanol fractions, the levels of DC, KD, and KT, MDA were the highest in the blood plasma of sows of the fourth group. The final product of LPO (Schiff base) in the heptane fraction of blood plasma of sows of the second and third groups turned out to be higher than that of sows of the first group.

Table 1. Indicators of prooxidant status in the blood of sows*

Index	Number groups of sows			
	First	Second	Third	Fourth
DC, optical density units/ml plasma (n-C7)	0.43±0.097	0.68±0.160	0.98±0.124	1.07±0.150
p	$p_{1-2}<0.01$, $p_{1-3}<0.01$, $p_{1-4}<0.01$, $p_{2-3}<0.01$, $p_{2-4}<0.01$, $p_{3-4}>0.05$			
DC, optical density units/ml plasma (IPA)	0.57±0.132	1.17±0.162	1.50±0.266	1.59±0.329
p	$p_{1-2}<0.01$, $p_{1-3}<0.01$, $p_{1-4}<0.01$, $p_{2-3}<0.01$, $p_{2-4}<0.01$, $p_{3-4}>0.05$			
KD и KT, optical density units/ml plasma (n-C7)	0.20±0.057	0.58±0.062	0.80±0.137	0.77±0.088
p	$p_{1-2}<0.01$, $p_{1-3}<0.01$, $p_{1-4}<0.01$, $p_{2-3}<0.01$, $p_{2-4}<0.01$, $p_{3-4}>0.05$			
KD и KT, optical density units/ml plasma (IPA)	0.65±0.166	1.34±0.096	1.49±0.116	1.64±0.156
p	$p_{1-2}<0.01$, $p_{1-3}<0.01$, $p_{1-4}<0.01$, $p_{2-3}<0.01$, $p_{2-4}<0.01$, $p_{3-4}<0.05$			
SBs, optical density units/ml plasma (n-C7)	0.11±0.048	0.08±0.021	0.12±0.043	0.20±0.039
p	$p_{1-2}>0.05$, $p_{1-3}>0.05$, $p_{1-4}<0.01$, $p_{2-3}>0.05$, $p_{2-4}<0.01$, $p_{3-4}<0.05$			
SBs, optical density units/ml plasma (IPA)	0.12±0.024	0.17±0.026	0.20±0.062	0.38±0.118
p	$p_{1-2}<0.01$, $p_{1-3}<0.01$, $p_{1-4}<0.01$, $p_{2-3}>0.05$, $p_{2-4}<0.01$, $p_{3-4}<0.01$			
MDA, mkmol/l	1.26±0.265	2.93±0.374	3.29±1.006	4.30±0.705
p	$p_{1-2}<0.01$, $p_{1-3}<0.01$, $p_{1-4}<0.01$, $p_{2-3}>0.05$, $p_{2-4}<0.01$, $p_{3-4}<0.05$			

*Composed by the authors.

As for the content of SBs in the blood of sows of the fourth group, their concentrations were higher in both the heptane and isopropanol fractions. The fact that the SBs content of the isopropanol fraction in the plasma of sows of the second and third groups was statistically significantly higher than that of animals of the first group indicates pronounced peroxidation processes in phospholipids. Considering their presence in the composition of cell membranes, the established changes are associated with their active destruction in hepatopathy.

The maintenance of physiological homeostasis in the body of sows is ensured by the presence of a certain balance between the pro-oxidant and antioxidant systems. AOS in sows varied variably, depending on the severity of the corresponding hepatopathy (Table 2).

The revealed dynamics of antioxidant and catalase activities, as well as the content in the blood of sows of the second group, indicate that during the acute course of hepatosis, the AOS of liver protection did not exhaust its functional reserve, which allowed it to effectively resist the action of pro-oxidant factors. This is indicated by both a statistically significant increase in the level of AOA and catalase activity (by 13.4 and 21.1 %, respectively) and relatively insignificant (by 3.3 and 4.9 %) decreases in the concentrations of vitamins *E* and *C* in the blood of pigs of the second group.

However, in sows with chronic hepatosis and liver cirrhosis, “suppression” of both enzymatic and non-enzymatic components of AOS occurred. Statistically significant decreases in catalase activity, TT, and ASC concentrations were noted in the blood of these animals.

Table 2. Indicators of antioxidant status of sows' blood*

Index	Number groups of sows			
	First	Second	Third	Fourth
AOA, mmol tocopherol /l	2.77±0.513	3.14±0.546	1.12±0.337	0.69±0.139
p	$p_{1-2}<0.05$, $p_{1-3}<0.01$, $p_{1-4}<0.01$, $p_{2-3}<0.01$, $p_{2-4}<0.01$, $p_{3-4}<0.05$			
TT, mkmol/l	19.47±5.226	18.85±5.132	12.50±1.281	5.89±1.924
p	$p_{1-2}>0.05$, $p_{1-3}<0.01$, $p_{1-4}<0.01$, $p_{2-3}<0.01$, $p_{2-4}<0.01$, $p_{3-4}<0.01$			
ASC, mkmol/l	72.38±22.730	68.97±5.955	35.83±7.340	29.88±6.202
p	$p_{1-2}>0.05$, $p_{1-3}<0.01$, $p_{1-4}<0.01$, $p_{2-3}<0.01$, $p_{2-4}<0.01$, $p_{3-4}>0.05$			
Catalase, kIU/l	54.61±5.664	66.16±8.677	45.98±5.080	38.91±5.032
p	$p_{1-2}<0.01$, $p_{1-3}<0.01$. $p_{1-4}<0.01$, $p_{2-3}<0.01$, $p_{2-4}<0.01$, $p_{3-4}>0.05$			

*Composed by the authors.

The latter is due to a decrease in the absorption of fat-soluble vitamin *E* (against the background of the chronic course of hepatopathy) (Ziyamutdinova, et al., 2023), and the synthesis of vitamin *C* in the liver (Kondrakhin and Levchenko, 2005). In addition, low appetite in sick animals leads to a decrease in the supply of vitamins to the body.

It should also be noted that against the background of an imbalance of LPO and AOS in the blood of sows of the second to fourth groups, an increase in the level of endogenous intoxication was noted, which was characterized by an increase in the content of MLMWS (Figure).

The development of hepatopathy in sows causes the presence of a "vicious circle": development of hepatopathy – activation of lipid peroxidation – destruction of hepatocytes – inhibition of the antitoxic function of the liver – increase in endogenous intoxication – development of hepatopathy. In this regard, the development of pharmacoprophylactic measures aimed at increasing the antioxidant protection of the body of sows becomes an urgent task in veterinary hepatology.

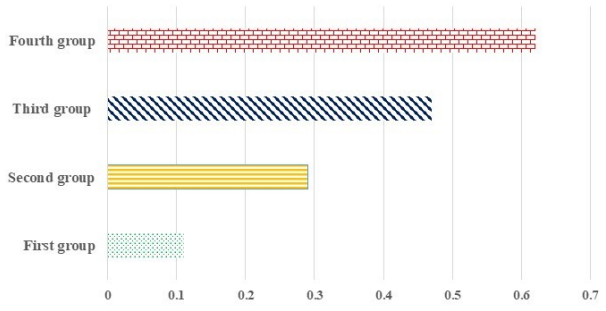

Figure. Content of MLMWS in the blood of sows, optical density units.

Conclusion

According to our sindings, in sows with hepatopathy there is an increase in the level of endogenous intoxication. This is due to the content of diene conjugates, diene ketones and conjugated trienes, malondialdehyde and TBA-active products, Schiff bases in blood.

These changes occur against the background of a decrease in the activity of the general antioxidant defense system. This includes catalase activity, and concentrations of tocopherol and ascorbic acid in the blood. High production of free radicals, "accumulation" in the body of primary and secondary end products of lipid peroxidation provoke, further irreversible destruction of the membrane structures of hepatocytes.

When hepatosis becomes chronic with the development of its terminal phase - cirrhosis, the intensity of oxidative changes in the body will increase, which will lead to a further increase in destructive processes in the liver. Therefore, the most significant changes in LPO and AOS parameters were detected in sows with liver cirrhosis.

Carrying out active pharmacoprophylactic measures in the early stages of the development of hepatopathy using natural and synthetic antioxidants will increase the antioxidant status of the sows' body, reduce the level of lipid peroxidation and prevent the development of irreversible processes in the liver.

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Declarations of interest

The authors declare no conflict of interest concerning the research, authorship, and/or publication of this article.

Accepted on 16.04.2024
Reviewed on 14.05.2024

AGRISCIENCE AND TECHNOLOGY
Armenian National Agrarian University
АГРОНАУКА И ТЕХНОЛОГИЯ
International Scientific Journal
ISSN 2579-2822

UDC 663.374.393 doi:10.52276/25792822-2024.2-149

Study of the Possibility of Honey Wine Production Using New Active Dry Yeasts and Yeasts Derivatives

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ARTICLE INFO

Keywords:
active dry yeast,
aroma spider graph,
honey wine,
molecular SO_2,
physicochemical analysis,
tasting

ABSTRACT

Honey wine, also known as a fermented beverage made from natural honey, is believed to be one of the earliest alcoholic drinks created by ancient humans thousands of years ago, long before the discovery of grape wine. Our research aims to produce wine from honey collected in the Armenian mountains. A series of articles dedicated to the study of the possibility of obtaining alcoholic beverages made by fermenting natural honey (honey wine) using different types of dry active yeast and yeast autolysis derivatives. The data obtained from the research results will be interesting from both the scientific and production points of view. This will allow us to conclude that the selected yeasts can be used for producing such alcoholic beverages.

Introduction

This is the second part of our research on honey wine samples produced using different yeasts and yeast autolysates from the alcoholic fermentation of diluted mountain Armenian honey. The first part of the Study describes the entire technological process of making honey wine, as well as the results and comments on the physicochemical investigations of the honey wine samples after fermentation. This research will compare the physicochemical results of the honey wine samples obtained after six months of storage and aging (Bakhshetsyan, et al., 2022). The second part of the article describes not only the physicochemical analysis of the samples but also includes the most important aspect of our research: tasting, to understand the flavors and profiles of our honey wine samples.

Materials and methods

This study aims to compare the physicochemical parameters of honey wine samples after fermentation and storage, as well as assess their tasting results. For an accurate representation of the tasting experience, we've crafted a specialized tasting form tailored for honey wine (mead). This process proved intricate due to the diverse ingredients often used in mead production, such as fresh fruit juice, berries, or other aromatic substances. In our research, the above supplements were not used, which is why the process is more complicated. These graphs visually represent the diverse aromatic profiles, allowing for a more nuanced understanding of the tasting results. The inclusion of such graphs enhances the clarity and precision of our evaluation process.

OIV and EAEU GOSTs methods were used to evaluate honey wine samples' physicochemical indicators. Sugar content was determined by refractometry and Bertrand methods (GOST 13192-73). Alcohol content: OIV-MA-AS312-01A, Total acidity: OIV-MA-AS313-01, Volatile acidity: OIV-MA-AS13-02, Free and total sulfur dioxide: OIV-MA- F1-07, Chromatic characteristics: OIV-MA-AS2-07B, Folin Chekoltau index with OIV-MA-AS2-10 methods (International Organization of Vine and Wine, 2022). Color characteristics were determined using a UNICO 2802 UV/VIS photo-spectrometer at 420, 520, and 620 nm in a 1-cm-thick cuvette.

Results and Discussions

As a result of laboratory research, the following physicochemical indicators of honey wine were studied: free sulfur dioxide, total sulfur dioxide, reductants, titratable, volatile and active acidity, amount of ethyl alcohol and sugars, total and dry extract, specific gravity, the total content of phenolic compounds, aldehydes, acetals, and Folin Chekoltau index (Table 1).

At low pH, the predominant species is molecular sulfur dioxide (SO_2), which exhibits germicidal properties. However, at the wine pH, the major species is the bisulfite anion, which acts as an antioxidant (Stockley, 2005). Sugar-sulfur dioxide complexes break down as sugar is metabolized during fermentation. All binding reactions can significantly reduce the free sulfur dioxide concentration in wine (Ronald and Jackson, 2008). The amount of free sulfur dioxide in the samples ranges from 23.65 to 34.41 mg/dm^3.

During storage and maturation, we added potassium metabisulphite to all samples to preserve honey wine from oxidation. This was to prevent changes in organoleptic and quality characteristics. As a result, sulfur dioxide-free and total amounts increased in five samples after six months of storage. As a result, in the VR-44 sample total concentration of sulfur dioxide became 129.94 mg/dm^3 from 35.4 mg/dm^3, AB-1 from 36.37 to 131.17 mg/dm^3, in the AS-2 sample from 41.39-126.87 mg/dm^3, TF-6 from 41.39 to 115.2 mg/dm^3. The highest sulfur dioxide total concentration was recorded for AC-4: from 37.6 to 132.65 mg/dm^3.

It is common to consider only the molecular sulfur dioxide content when assessing antimicrobial action.

Table 1. The results of the physicochemical analysis*

Parameters	Unit	SafOENO VR-44	SafCider AB-1	SafCider AS-2	SafCider AC-4	SafCider TF-6
Free sulfur dioxide	mg/dm^3	23.96	23.96	34.41	25.49	23.65
Total sulfur dioxide	mg/dm^3	129.94	131.17	126.87	132.65	115.2
Reductons SO_2	mg/dm^3	2.15	2.45	3.07	2.15	3.38
Molecular SO_2	mg/dm^3	1.58	1.62	2.27	1.61	1.34
Titratable acidity	g/dm^3	4.05	3.9	3.97	3.97	3.82
Volatile acidity	g/dm^3	0.64	0.67	0.95	0.75	1.07
Active acidity, pH	-	2.96	2.95	2.96	2.98	3.03
Alcohol, by vol.	%	12.4	12.4	12.5	12.5	12.5
Sugars	g/dm^3	12.45	13.0	13.02	12.72	13.1
Total Extract	g/dm^3	44.70	43.60	44.90	39.60	41.8
Dry Extract	g/dm^3	32.25	30.60	31.88	26.88	28.7
Density	g/dm^3	1.0173	1.0169	1.0174	1.0153	1.0162
Total phenols	mg/dm^3	143.16	142.21	136.85	136.47	137.95
Folin Chekoltau Index	-	3.25	3.23	3.11	3.10	3.13
Aldehydes	mg/dm^3	43.12	49.28	36.96	39.16	35.64
Acetals	mg/dm^3	29.5	25.96	29.5	63.72	9.44

*Composed by the authors.

Of the free states of sulfur dioxide, molecular SO_2 is the most readily absorbed by microbes. However, as the cytoplasm typically has a pH of around 6.5, the molecular form quickly changes into its ionic states, bisulfite and sulfite. The binding of these ions with various cellular constituents enhances the continued uptake of sulfur dioxide. The level of free sulfur dioxide required to obtain a desired amount of molecular SO_2 can be partially estimated by dividing the desired value by the percentage of molecular SO_2 at the wine's pH. As sulfur dioxide binds with carbonyls and phenolics, the percentage of free and total SO_2 declines, until it reaches a new equilibrium between its bound and free forms (Ronald, 2008). The amount of molecular SO_2 in our samples was as follows: VR-44: 1.58 mg/dm^3, AB-1: 1.62 mg/dm^3, AS-2: 2.27 mg/dm^3, AC-4: 1.61 mg/dm^3, TF-6: 1.34 mg/dm^3. Based on the obtained data, we can say that the wines were stable. The presence of ascorbic acid can affect reductones. Reductones decreased by almost one mg/dm^3. The minimum amount was 2.15 mg/dm^3 in the VR-44 and AC-4 samples. Samples AS-2 and TF-6 had the maximum amounts, 3.07 mg/dm^3, and 3.38 mg/dm^3 respectively.

There was no significant change in titratable acidity results in the studied samples. The increase in titratable acidity in samples AS-2 and TF-6 can be attributed to residual sugar. An increase in titratable acidity and residual sugar occurred in sample VR-44. The titratable acidity results were as follows: minimum amount observed in sample TF-6, 3.82 g/dm^3, maximum amount observed in VR-44, 4.05 g/dm^3.

Volatile acids can increase due to oxidation or lactic acid fermentation. Because there was residual sugar in the samples, the decrease in volatile acidity may be due to the formation of new acetic acid esters. The amount of volatile acids changed irregularly: AB-1 sample decreased from 0.72 g/dm^3 to 0.67 g/dm^3, VR-44 increased from 0.54 to 0.64 g/dm^3, AS-2: 0.86-0.95 g/dm^3, AC-4 increased from 0.64 g/dm^3 to 0.75, TF-6 increased from 0.94 g/dm^3 to 1.07 g/dm^3. The change was 0.05-0.13 g/dm^3.

During honey wine maturation and storage, the pH decreases. The amount of mineral matter in the samples was low, salts of weak acids were also low and the slight change in titratable acidity during aging affected the pH. Active acidity in the samples before storage was 3.00-3.04. The acidity in the samples after storage was 2.95-3.03.

Interestingly, the amount of ethyl alcohol increased by 0.2 % in the four investigated samples and by 0.6 % in the TF-6 sample. This means that the amount of residual sugar during storage was converted into alcohol by slowly ongoing fermentation.

There was also a change in residual sugar amounts. Sample AB-1 did not change. In samples VR-44, AC-4, and AS-2 there was an increase in residual sugar by 0.87 g/dm^3, 0.57 g/dm^3, and 0.62 g/dm^3, respectively, which can be explained by the breakdown of polysaccharides contained in honey, which was realized as a result of the autolysis of the yeast, as a result of the breakdown of the enzymes that pass into the wine. A decrease in residual sugar occurred only in sample TF-6, from 19.55 g/dm^3 to 13.2 g/dm^3, which is explained by alcoholic fermentation.

The total and dry extracts of honey wine samples have also been determined. All substances that dissolve in wine and remain after distillation (evaporation) of the water-alcohol part are called total extracts, which is the total amount of all non-volatile substances dissolved in the wine, because we used different yeasts, which were originally intended for the production of fruit wine, and cider (Bakhshetsyan, et al., 2022), including carbohydrates, glycerin, non-volatile acids, nitrogen compounds, tannins and dyes, higher alcohols, and minerals. Since we used different yeast and the raw materials were the same, the difference depends on the difference in the amount of glycerol and succinic acid produced by the yeast.

Glycerol ranks as the most important fermentation product after ethanol and carbon dioxide. It is involved in osmotic cell regulation (Blomberg and Adler, 1992). Many growth and environmental factors influence the amount of glycerol produced by yeast in wine, e.g., sulfite concentration, pH, and nitrogen composition (Ough, et al., 1972). The amount of dry extract in the investigated samples was as follows: VR-44: 44.70 g/dm^3, AB-1: 43.60 g/dm^3, AS-2: 44.9 g/dm^3 AC-4: 39.60 g/dm^3, TF-6: 41.8 g/dm^3.

The content of phenolic substances in honey wine samples varied from 136.47 mg/dm^3 to 143.16 mg/dm^3. Because no additional tannins were added, phenolics after storage increased by 30 mg/dm^3 to 12.57-30.55 mg/dm^3. We assume that the increase in the total concentration of phenolic compounds could have occurred due to yeast cell autolysis (Bakhshetsyan, et al., 2022).

The Folin-Chekoltau index is an international method for determining the total content of phenolic compounds (International Organisation of Vine and Wine). In mature samples, this indicator increased. The results were as follows: VR-44 – 3.25, AB-1 -3.23, AS-2 – 3.11, AC-4 – 3.10, TF-6 – 3.13 (Table 2).

Table 2. Color characteristics of honey wine*

Parameter	SafCEnoTM VR-44	SafCider AB-1	SafCider AS-2	SafCider AC-4	SafCider TF-6
Absorption coefficient					
A420 Yellow	0.1194	0.1311	0.1494	0.1019	0.1106
A520 Red	0.0395	0.0463	0.0615	0.0325	0.0395
A620 Blue	0.0261	0.0309	0.0429	0.0214	0.0272
Color intensity	0.18	0.21	0.25	0.16	0.18
Color shade	3.02	2.83	2.43	3.13	2.8
Color composition (%)					
A420 Yellow	64.6	62.9	58.9	65.4	62.3
A520 Red	21.4	22.2	24.2	20.9	22.3
A620 Blue	14.1	14.8	16.9	13.7	15.4

*Composed by the authors.

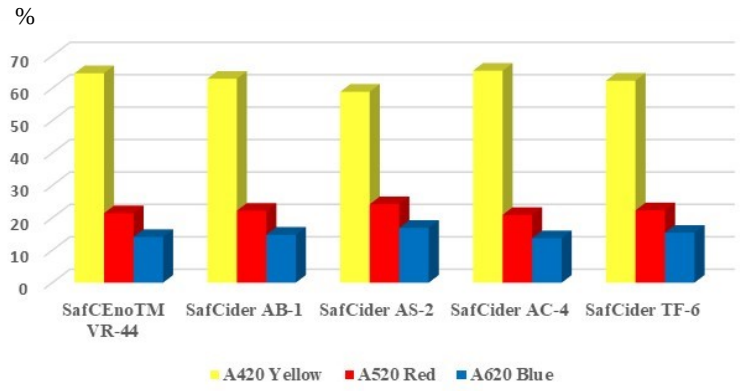
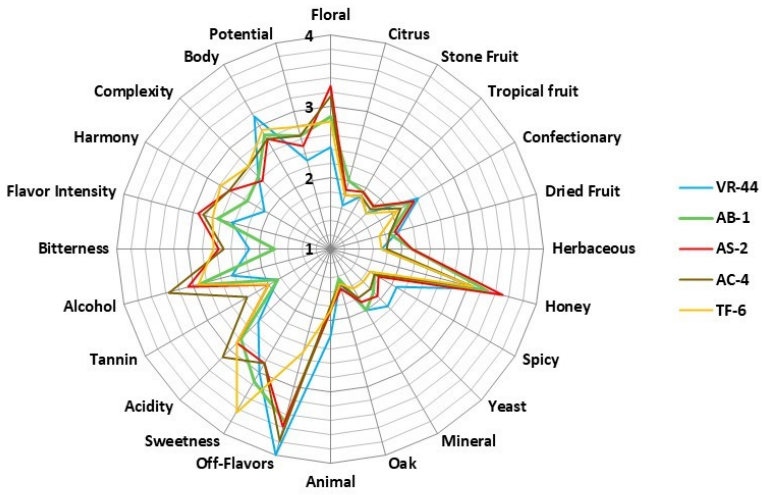


Figure. Color composition *(composed by the authors)*.

Chemical processes of the natural storage mechanism can lead to the oxidation of phenolic compounds and other reducing agents, the formation of aldehydes, acetals, and esters, and the hydrolysis of polysaccharides and glucosides (Ribereau-Gayon, et al., 2006). After storage, the total amount of aldehydes in the VR-44 sample increased from 30.8 to 43.12 mg/dm^3, AB-1 from 36.96 to 49.28 mg/dm^3, AS-2 from 89.76 mg/dm^3 to 36.96 mg/dm^3, AC-4 from 34.76 -39.16 mg/dm^3, TF-6: from 47.08 mg/dm^3 to 35.64 mg/dm^3.

The total amount of acetals in the samples changed significantly. In samples VR-44, AS-2, TF-6 it decreased, respectively 29.5 mg/dm^3, 29.5 mg/dm^3, 9.44 mg/dm^3. The quantity of AB-1 and AC-4 increased by 25.96 mg/dm^3 and 63.72 mg/dm^3, respectively. There are many shades of honey wine, from transparent to dark amber.

The chemical changes that occurred during storage also became the basis for the change in the wine color. In all five samples, the percentage of yellow color in the color composition increased, while the percentage ratio of red and blue colors decreased. The color intensity changed significantly during storage. Intensity decreased in all samples. It decreased from 0.83 to 0.18 in the VR-44 sample, from 0.4 to 0.21 in the AB-1 sample, AS-2 from 0.39 to 0.25, AC-4 from 0.4 to 0.16, and TF-6 from 0.44 to 0.18 (Table 2, Figure).



Wheel graph. Honey wine aroma wheel *(composed by the authors)*.

The tasting form is thoughtfully designed to capture the nuanced flavors, and aromas inherent in each honey wine sample. To accommodate this complexity, our tasting form provides a comprehensive assessment framework. One distinctive feature of our tasting form is the inclusion of aroma wheel graphs for each honey wine sample (Wheel graph).

During the tasting, the participants appreciated the aroma and taste of the wines and left a general impression of the samples. For the tasting, a special evaluation sheet was compiled according to a five-point system, in which the following indicators were evaluated: from aromas: floral, stone, citrus, tropical, dried fruit, honey, confectionery, herbal, yeast, spicy, oak, animal, off-flavors, mineral, to taste: sweetness, acidity, tannins, alcohol, bitterness, intensity of taste. The indicators of the overall rotation are harmony, diversity, physicality, and potential.

Based on the opinions of the tasting participants, we have compiled a wheel of flavors from five samples. The wheels of aromas provide an opportunity to better describe wine's peculiarities the olfactory characteristics. VR-44, being a test version of the study samples, showed the following positive results: honey shades are well expressed, as well as a floral bouquet, yeasty aromas are also noticeable, the most unpleasant aromas were found in this sample, it is fleshier compared to other samples. The VR-44 sample has the highest body and spicy notes. Alcohol is not strongly noticeable during tasting, due to glycerin.

The AB-1 yeast sample used is distinguished by its high floral and herbaceous aromas, with well-defined honey notes. pastry aromas are also noticeable, and mineral-origin aromas are faintly noticeable. This sample stands out for its citrus tones and interesting sweetness, with no bitterness. As a negative aroma, tasters noted the presence of off-flavors, which is acceptable in honey wine's aromatic bouquet. International experience shows that any wine made from honey has characteristic side aromas (Kay Senn, et al., 2020).

The AS-2 sample did not change significantly during the study, but after storage, it acquired different properties. The Honey, flowers, and stone fruit aromas were well expressed. The intensity of taste and bitterness complements each other. Among the used yeasts, AS-2 showed the best results.

AC-4 has pleasant acidity and spirit, and a fresh floral aroma is noticeable. Among the samples, the quantity and variety of tannins are mentioned only here. The highest level of acidity is expressed in this sample.

According to the participants of the tasting, the best option is TF-6, because the unpleasant aromas are not clearly expressed, and the aromas of stone fruits are pleasantly emphasized, although the honey or floral aromas are not

significantly expressed here. Let's take into account the fact that this sample was fermented for the longest without losing its quality characteristics. The data show that this sample is the wine with the greatest potential.

Taking into account the fact that honey wines are not produced in Armenia, the participants of the tasting, not having experience of evaluating honey wine, gave their opinions on the studied samples according to the same pattern as wines made from grapes.

Conclusion

According to studies, Ferment is dry yeast and derivatives can be used to produce honey wine. The laboratory tests confirmed that the wines have high-quality characteristics, and the tasting results indicated that they had rich olfactory characteristics. A wide range of quality and taste characteristics can be achieved with the yeast used. Based on the research results, the AS-2 sample showed the best taste indicators. The AS-2 sample stands out for its maximum floral, herbaceous, and honey tones, strongly expressed aromas of tropical fruits and stone fruit, as well as dry aromas. The unique style of the wines has aroused great interest. As a result, in the future, we will clarify the possible options for reducing the fermentation period and improving the wine quality. We will also carry out new studies on the drinks obtained from the alcoholic fermentation of honey.

In conclusion, our specialized tasting form, complete with aroma wheel graphs, serves as a sophisticated tool to capture honey wine flavors. This innovative approach ensures that the tasting results are not only comprehensive but also visually accessible, making it an invaluable resource for enthusiasts and connoisseurs alike.

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Acknowledgements

This research was carried out with the support of the Innovative Agriculture Training and Learning Camp (AGRI CAMP) Program which is financed by The United States Agency for International Development (USAID) and implemented by the International Center for Agribusiness Research and Education Foundation (ICARE). The contents are the responsibility of the author/s and do not necessarily reflect the views of USAID or the United States Government.

Declarations of interest

The authors declare no conflict of interest concerning the research, authorship, and/or publication of this article.

Accepted on 01.03.2024
Reviewed on 26.04.2024

AGRISCIENCE AND TECHNOLOGY
Armenian National Agrarian University
АГРОНАУКА И ТЕХНОЛОГИЯ
International Scientific Journal
ISSN 2579-2822

UDC 637.146.34 doi: 10.52276/25792822-2024.2-156

The Use of Pine Cone Extract in the Production of Albumen Curd

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ARTICLE INFO

Keywords:
albumen curd,
extract,
pine cone,
whey,
whey protein

ABSTRACT

Due to a lack of protein in the human diet, dairy products made from milk proteins have increased in production. The proposed new product was made from cheese whey and curds. The main ingredients were whey proteins and pine cone extract as a natural additive. The relevance of making albumen curd with vegetable extract is scientifically and experimentally justified. Based on this study, the optimal dose of pine cone extract was determined which results in imparting a distinctive taste and aroma characteristic of pine cone, improving the chemical composition, and extending the product's shelf life.

Introduction

Nowadays, secondary raw materials are highly relevant for the production of foods. Dietary protein deficiency can lead to various diseases in the elderly and young children, spurring a significant trend toward producing protein-rich foods to prevent them. Whey albumen proteins are considered complete because they can complement the list of protein-rich foods (Food Industry, 2022).

The production of the new type of food will expand the wide range of protein-dairy products, as well as enhance the chemical composition of the food and extend the shelf life (Galstyan, 2018; Dilanyan, 2000).

Pine cone extract is a rich source of biologically active substances, which have a rich chemical composition and antioxidant properties. (sfera.fm)

Currently, the use of secondary raw materials such as whey allows for the expansion of product range and volume while reducing costs. The whey proteins can meet the needs of the elderly, athletes, and people engaged in various complex physical activities.

Materials and methods

Albumen curd is prepared using the technology typical for this protein product. Whey is an excellent source of nutrients and offers many health benefits. It contains

more than 200 beneficial substances essential for the full development of the human body. In addition, it has high nutritional value (Rodionov, et al., 2020).

The composition of whey is as follows: 6.3 % dry matter, 0.9% proteins, 0.3 % milk fat, 4.5 % lactose (Khramtsov, et al., 2018)

Whey contains 80 % minerals (*Ca, Fe, Mg, P, K, Na, Zn, Cu, Mn, Se*). It boosts immunity, helps with joint inflammation, regulates the body's metabolism, and positively affects gastrointestinal microflora (Yevdokimov, 2009).

A cone is a modified fruit found at the tops of branches, primarily in gymnosperms such as spruce, pine, cedar, and juniper. Tincture of cones can be used for inhalation and therapeutic procedures. The use of pine cones ensures improvement of blood circulation by strengthening blood vessels, significantly increases immunity, prevents heart attacks, accelerates metabolism, enriches the body with minerals, which contributes to the rapid strengthening of bones, regulates blood pressure, aids in blood recovery after internal bleeding, and provides a relaxing and tonic effect. Additionally, it promotes positive changes in the function of the organs of vision (sfera.fm).

Considering the Figure, the new food will have a great application value due to its full composition rich in vitamins, amino acids, proteins, and minerals. The main aim of the study was to obtain a new kind of albumen curd, rich in vitamins, amino acids, proteins, and minerals.

To achieve the goal, the following issues were raised:

To make albumen curd from cheese whey.

To investigate the effect of pine cone extract on the sensory indicators and the shelf life of the food produced.

To decide the optimum dosage of pine cone extract used for albumen curd production.

To study the sensory, physicochemical, and microbiological processes of albumen curd with pine cone extract.

Whey, pine cone extract, albumen curd, and albumen curd with pine cone extract samples were the object of the research. During the work, a study of the physicochemical, microbiological, and sensory indicators of the raw material, albumen curd with plant extract was performed.

The composition of pine cone extract:

Picture 1. Pine cone extract.

Nutritional value is 244.0 KCal / 1024.8 KJ, carbohydrates: 61.0 g, stored at 0-25°C with no more than 75% relative humidity. After opening, store in the refrigerator for up to 1 month. Shelf life is 36 months from the date of manufacture (Picture 1).

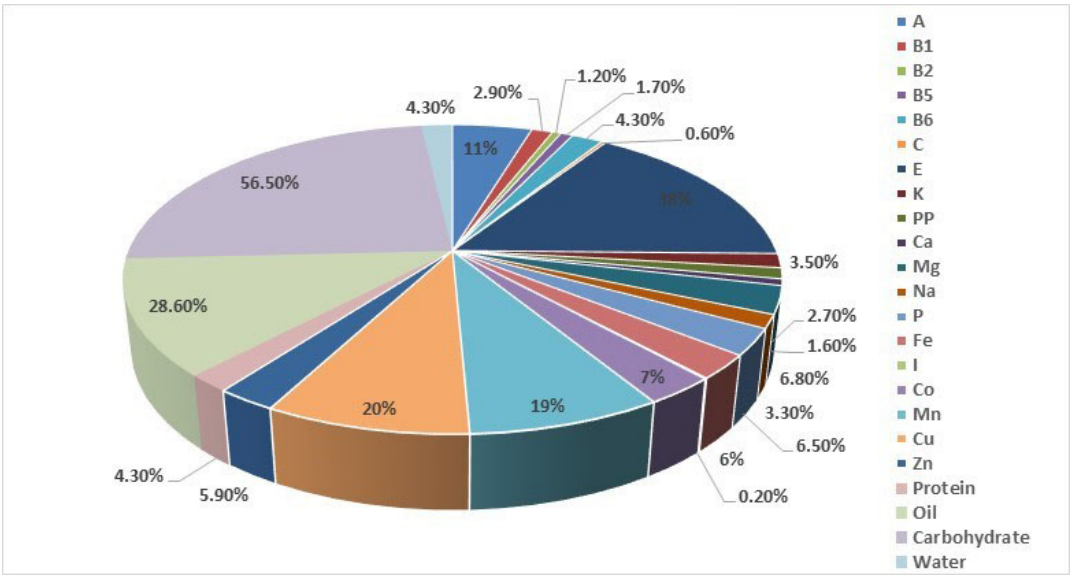

Figure. The Chemical composition of the pine cone extract (health-diet.ru)

Cone juice, also known as the elixir of health, is obtained from young, green pine cones using a special traditional technology. The use of pine cone extract is effective for boosting immunity, strengthening the body's defense mechanisms, and treating various conditions such as rheumatism, metabolic disorders, colds, bronchial asthma, bronchitis, and coughs of various origins, among other diseases (sfera.fm).

Results and discussions

Control and test samples of albumen curd were prepared in the production of "Daughter Marianna" LLC, and the experiments were carried out in the laboratory of the abovementioned production.

The following study was conducted:

Study of physicochemical indicators of whey

Study of pine cone extract according to normative documents

The use of pine cone extract in the production of albumen curd

Investigation of physicochemical, sensory, and microbiological indicators of the new product

Contribution and summary of scientific results

Classically accepted scientific research methods were used during the study (Aydinyan and Chatinyan, 2009). Whey, pine cone extract, and the finished product were investigated.

Sensory indicators of pine cone extract- color - brownish-green, taste typical of a pine cone, without extraneous taste and smell, consistency - certain thickness, without sediment. (Tsaturyan, et al., 2014). Sensory indicators of whey - color - slightly yellowish, taste - natural lactic acid, without extraneous taste and smell, consistency - certain thickness, with an expressed somewhat sediment.

Physicochemical indicators of whey used for the preparation of test and control samples are fat content of 0.6 %, titratable acidity: of 15 ^{0}T, density: of 1025kg/m^3, lactose: of 4.5 %, and protein amount: of 0.9 % (Picture 2).

The following processes were carried out to obtain albumin curd from the investigated whey:

- *Heat Treatment:* Heat the pasteurized whey to 90-95 ^{0}C.
- *Acid Addition:* Add lactic acid (0.001 %) to the whey.
- *Protein Precipitation:* Allow the proteins to precipitate.
- *Self-Pressing:* Let the mixture self-press.
- *Pressing:* Press the mixture for 1.0-1.5 hours.
- *Pine Cone Extract Addition:* Add the pine cone extract.

Picture 2. Milk whey.

Picture 3. The new product.

Table 1. Additive Pine Cone Extract Doses*

A sample	The amount of pine cone extract%	The amount of albumen curd in gram
Control	0	100
Test 1	9	100
Test 2	10	100
Test 3	11	100

*Composed by the authors.

To the finished albumen curd, add the solution of the cone in the appropriate proportions, as presented in the table 1.

The additive pine cone extract dosage chart shows the amounts expressed in %. It can be seen in the table that in the control sample, the albumen curd was 100 grams, and in the test samples, pine cone extract was added at 9%, 10%, and 11% and measured per 100 grams. The results of the physicochemical and sensory indicators of the samples with the indicated dosages are presented in Table 2.

As a control option, albumen curd was prepared in the manner mentioned above. The test samples were prepared by adding different amounts of cone extract. The moisture content of the control and test products was determined using an ELVIS-2 hygrometer. The test samples were prepared at "Daughter Marianna" LLC (Picture 3).

Table 2. The effect of pine cone extract on albumen curd's physicochemical and sensory indicators*

The indicators	Test options			
	Test 1	Test 2	Test 3	Control
The amount of increase of the pine cone extract, %	9.0	10.0	11.0	-
Titratable acidity, °T	59	58	56	60
Mass fraction of oil, %	7	7	7	7
Mass fraction of water, %	69.79	69.80	69.92	73.2
The amount of carbohydrates, %	7.49	8.10	8.71	2
Appearance	With a very faint extract hue throughout	With a subtly pronounced distinctive extract hue throughout	With a pronounced extract hue throughout	With a fine whitish-yellow hue throughout
Taste and smell	Lactic acid without extraneous taste and smell, very faint taste and smell of cone extract	Lactic acid without extraneous taste and smell, slightly pronounced cone extract taste and smell	Lactic acid without extraneous taste and smell, pronounced taste and smell of bright cone extract	Lactic acid without extraneous taste and smell, characteristic of albumen curd
Color	With an unexpressed hue	Expressed with a subtle hue	Expressed with hue	With a whitish-yellow hue

Table 3. Microbiological parameters of the new food with pine cone extract*

Name of the indicators	The permissible level of mg/kg, not more	Additions	According to the results	Compatibility
Microbiological indicators				
MAFAM	$1x10^6$ GAM/cm^3 /g/, not more	-	$1x10^4$	Compatible
Pathogen, a/t salmonellas	25 g/cm^3 in food	not allowed	-	Compatible
Staphylococcus S.aureus	0.1g/cm^3 in food	not allowed	-	Compatible
Yeast	50 GAM/cm^3 (g) not more	-	10	Compatible
Mold	50 GAM/cm^3 (g) not more	-	5	Compatible

*Composed by the authors.

As a result of the research presented in the table above, different dosages of pine cone extract were used as a natural supplement and the optimal dosage was determined based on physicochemical and sensory indicators. The control and test samples were aged at a temperature of 2-6 ^{0}C, as a result of which the control sample had a shelf life of 72 hours and the test sample had a shelf life of 100 hours. According to the results of the research, high sensory and appropriate physicochemical indicators were recorded, as well as an extension of the shelf life was observed in sample 2.

From the table of microbiological indicators of the new product with pine cone extract, it is evident that with the use of extract, the product meets the specified requirements.

Conclusion

Considering the results of the scientific research, and theoretical and experimental works, the following conclusions and recommendations were made. The composition of whey is enriched with easily digestible carbohydrates, vitamins, and minerals. Enriching new food with carbohydrates, vitamins, and minerals was theoretically justified and experimentally confirmed. As a result of the research, the use of 10% pine cone extract was selected as the optimal dosage, as relatively high sensory indicators and extended shelf life were reported at this dosage. As a result of the research, it was found that the use of extract contributes to the production of food with new unique taste properties, and high nutritional and biological value. As a result, it acquires a rich chemical composition, a unique taste, and smell, and a homogeneous fine coloring.

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Declarations of interest

The authors declare no conflict of interest concerning the research, authorship, and/or publication of this article.

Accepted on 27.02.2024
Reviewed on 08.04.2024

AGRISCIENCE AND TECHNOLOGY
Armenian National Agrarian University
АГРОНАУКА И ТЕХНОЛОГИЯ
International Scientific Journal
ISSN 2579-2822

UDC 637.518 doi: 10.52276/25792822-2024.2-161

Ingredients and Technical Parameters of a New Type of Semi-Finished Meat Containing Dutch Cabbages

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ARTICLE INFO

Keywords:
Cutlet,
Dutch cabbage (white cabbage),
fiber,
semi-finished food,
Sensory and physicochemical indicators

ABSTRACT

Increasing demand for semi-finished meat has led manufacturers to increase production volumes, renewing and modernizing their assortments in parallel. Technologies and recipes for semi-finished products production are known, in which animal and vegetable raw materials are combined. In addition, it contributes to the rational use of raw materials, the provision of quality food, and the improvement of technical and economic indicators. As a dietary raw material, white cabbage is an effective raw material to use in the production of semi-finished products.

Introduction

Slaughtered animals and birds are considered valuable food products. As a result, it contains almost all of the nutrients the human body needs to function normally. The human body can completely assimilate meat proteins, unlike vegetable proteins. Meat's total protein content does not fully describe its nutritional value, since different parts of meat contain incomplete and complete proteins in varying proportions. Raw materials of plant origin are increasing in meat products for this reason (Antipova and Zherebtsov, 1991). The quality of meat products decreased along with the increase in meat products. This may be due to the increase in meat raw materials prices and the shortage.

The purpose of this research is to find a solution to this problem. It is based on the development of the recipe and production technological parameters of a new type of semi-finished meat, with the partial replacement of meat raw materials with plant raw materials.

We were interested in using white cabbage in the production of vegetable semi-finished products, specifically cutlets, after studying various research works. Because cabbage has such high quality and useful properties, we concluded that its use will be more effective in producing meat semi-finished products (www.xcook.info).

Besides being rich in minerals and vitamins, cabbage contains 87 % water, 3.9 % sugars, 3.3 % nitrogenous

substances, 1.2 % fiber, and 35-50 mg/% aspartic acid. Vitamin *C* is naturally found in cabbage. There are more of these valuable compounds in cabbage than in subtropical lemons and oranges. Cabbage is also an excellent source of *B, P,* and *K* vitamins. As well as sulfur, calcium, potassium, and phosphorus, cabbage contains a bactericidal enzyme called lysozyme.

Cabbage is also rich in phytoncides, and due to its low carbohydrate content, it is a great food for diabetics. The protein content of cabbage is higher than that of carrots and beets. Amino acids (threonine, lysine, methionine) are found in cabbage proteins, which help regenerate and grow tissues, stimulate hematopoiesis, improve thyroid gland function, stimulate kidney and adrenal gland function, and solve and remove foreign proteins that are harmful to the body. In cabbage, there is almost no starch, and the sugar content is low, which makes it suitable for diabetics (www.Fitaudit.ru; www.syl.ru).

Material and methods

It is the objective of this research to develop the technical parameters for producing semi-finished meat with white cabbage, to determine the composition, to calculate the cost of a new type of semi-finished product, to determine the right amount of cabbage to add, and to examine the finished product from a sensory and physicochemical perspective. Sensory and physicochemical research determines cabbage's effects on semi-finished products, technological processes, and the quality of finished products.

The test samples were prepared, tasted, and analyzed in the laboratory by "Bacon Product" LLC. The samples were prepared with the same technological process, with partial substitution of meat raw materials. In three samples, raw meat was partially replaced by white cabbage in the following proportions:

1. Adding 6 kg of white cabbage per 100 kg of raw material
2. Adding 8 kg of white cabbage per 100 kg of raw material
3. Adding 10 kg of white cabbage per 100 kg of raw material

The ingredient was tested for sensory and physicochemical effectiveness. As a test sample, the "homemade" cutlet was prepared according to GOST 32951-2014 (technical regulation of the EEU Customs Union 034 on meat and meat products safety). These studies led to the selection of the options with the highest positive indicators.

Table 1 shows an increase of 8 kg in white cabbage. Due to the mass, the moisture in the product reaches 74.8 %, the minced meat is homogeneous (typical of minced beef for cutlets), and the taste and smell are well expressed.

Table 1. Sensory and physicochemical parameters of cutlets influenced by white cabbage amounts

Raw material type	Quantity %	Moisture %	Sensory evaluation
Dutch cabbage	6	72.9	Taste and smell correspond to the cutlet›s taste and smell, homogeneous consistency (typical of patty mince), characteristic color
Dutch cabbage	8	74.8	Well-defined taste, well-defined cutlet characteristic smell, homogeneous fine consistency (characteristic of cutlet mince), characteristic color
Dutch cabbage	10	75.6	Weak flavor, poor smell, a non-homogeneous consistency, and a lighter color

*Composed by authors.

As a result of adding 6 kg of white cabbage, version 1 mince was homogenous, tasted and smelled well, and had a moisture content of 72.9 %. As a result, there have been almost no changes observed compared to the control sample, there are almost no changes observed. This allows us to conclude that partial meat raw materials replacement is not appropriate in this case. As a result of the third version, the minced meat had a faint meat taste, the cabbage taste was dominant, a slightly bitter aftertaste, a weak odor, a non-homogeneous consistency (unusually for minced meat used for cutlets), a lighter color, and 75.6 % moisture content.

Table 2. The ingredients of check and test samples*

Names of raw and main materials	Test sample.kg	Check sample. g
2nd type of without-tendon meat	34	43
Semi-fatty pork meat	34	45
Cellulose	12	-
White cabbage	8	-
Breadcrumbs	6	6
Salt	1.5	1.5
Black pepper	0.03	0.06
Onion	4	4
Egg	2	2

*Composed by the authors.

Table 2 shows that white cabbage with a mass of 8 kg per 100 kg of raw material was the optimal criterion. As a result of adding white cabbage to test samples, excess water was created, resulting in poor quality. As a precaution, we added a highly water-absorbent component. So in this case, fiber was decided upon as it has water-binding properties and is common in the production of meat semi-finished products (Zabashta, et.al, 2001). After the mincemeat had been prepared, it was shaped, arranged in boxes, and frozen.

The cutlets can be stored for 1 month at -10 ^{0}C (Araksyants et al., 2005; Irkitova, 2017). It is therefore possible to make a new type of cutlet with white cabbage using fiber, as shown in the table. As with all meat products, cutlet recipes were also given per 100 kilograms of raw material.

Table 3. Production parameters for white cabbage cutlets*

Parameter name	Index
Raw material acceptance	12-16ºC
Cutting	0,5-1 kg
Remove bones and tendons	10-16ºC
Grinding with a meat grinder	10-16 mm
Cabbage shredding	8 kg
Cellulose preparation	12 kg
Minced meat preparation	10-15 ^{0}C, 7-10 minute
Shaped into patties, Coating with breadcrumbs	75-100 gr
Storage, packaging	-10, -11 ^{0}C, 1 month

*Composed by the authors.

The control sample contains 10 kg more meat raw material than the experimental sample, as shown in Table 3. Consequently, the consumer will benefit from a product richer in carbohydrates and vitamins due to its partial replacement with white cabbage, which will reduce the cost of the finished product. It is possible to determine technological parameters for producing fiber-rich cutlets after studying all the changes and results.

Results and Discussions

The semi-finished products were assessed using an average sample. Sampling is performed from different parts of the batch, depending on the volume of the semi-finished product, in the following quantities: 3 units (up to 10-unit packs), 5 (11 to 100 unit packs), 10 (101 to 1000 unit packs), etc. 10 samples of semi-finished products are taken from these packages for physicochemical tests (Hambardzumyan, 2008; Senchenko, 2001). Lab tests were performed at “Bacon Product” LLC, and the results are presented in the Table 4.

Because the test sample had a high moisture content, the semi-finished product became more delicate, and the low-fat content made it easier to digest (Table 5). The amount of fats and proteins and the amount of energy they release are the most important indicators of a food’s nutritional value (Senchenko, 2001).

Table 4. Control and test cutlets’ sensory indicators*

Index name	Check sample	Test sample
Product appearance	Shaped and coated with breadcrumbs, no cracks	
The taste	After roasting, the flavor of onions was evident, salty	After roasting, it was delicate, slightly pronounced taste, salty
The smell	characteristic of a given type of semi-finished product	delicately expressed, characteristic of a given type of semi-finished product
Consistency	Thick consistency, a bit of a stretchy	Thick, tender, juicy

Table 5. Physicochemical indicators of check and test cutlets*

Index name	Check sample. %	Test sample. %
Moisture	64.84	74.8
Fat content	15.3	10.6
Minerals (including salt)	1.6	1.8
Salt	1.91	1.68
Protein content	16.35	11.12

*Composed by the authors.

Table 6 shows that 100 grams of our cutlet with fiber and white cabbage contain 178.28 kcal of energy, while 100 grams of the control contain 203.1 kcal. In addition to the

ease of digestion of the new type of cutlet prepared by us, the addition of fiber and white cabbage also contributes to the cutlet's carbohydrate content. Taking into account the finished product output, raw materials and auxiliary materials must first be calculated for meat semi-finished products. Since the addition of fiber leads to an increase in the finished product yield, it is necessary to perform a raw material calculation.

Table 6. Energy value of fiber cutlets*

Index name	Check sample	Test sample
Protein content, %	16.35	11.12
Fat, %	15.3	10.6
Carbohydrates. %	-	9.6
Energy value, kCal	203.1	178.28

Table 7. Calculation of check and test sample cost*

Names of raw and main materials	Test sample, kg	Cost, 1000 AMD	Check sample, kg	Cost, 1000 AMD
2nd type of without-tendon meat	29.82	65.6	43	94.6
Semi-fatty pork meat	29.82	53.68	45	81
Cellulose	10.52	10.52	-	-
White cabbage	7.01	1.05	-	-
Breadcrumbs	5.26	0.79	6	0.9
Salt	1.32	0.13	1.5	0.15
Black pepper	0.026	0.039	0.06	0.09
Onion	3.75	0.5	4	0.6
Egg	1.75	1.2	2	1.3
Total cost, AMD		133.2		178.64

*Composed by the authors.

According to the calculation, one kilogram of cutlets with white cabbage will cost 133.5 AMD. The test sample cost AMD 1786.4 per 1 kg. White cabbage was used in the experimental sample in place of expensive meat raw materials, which explains the low cost of 1 kg of the sample at 451.33 drams.

Conclusion

There is a need to control not only the receipt and preservation of meat raw materials in factories to obtain high-quality meat raw materials, but also the correct maintenance of technological processes, the condition of production equipment, and the composition of new products to ensure meat raw materials are safe and high-quality.

Based on the scientific work, we can conclude:

The recipe for a novel semi-finished product was developed, in which meat raw materials were partially replaced by vegetables, which have high-quality characteristics in comparison with the test sample. Sensory and physicochemical indicators were used to assess the quality of a newly developed semi-finished product; It contained 178.28 kcal of energy.

Based on the cost of check and test samples, it was proven that the new formulation reduced the cost per kilogram by 454.33 AMD. In light of the conclusions, it can be suggested that: To provide consumers with high-quality and easy-to-use food and to enhance the efficiency of meat processing organizations, this novel type of semi-finished product needs to be produced.

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Declarations of interest

The authors declare no conflict of interest concerning the research, authorship, and/or publication of this article.

Accepted on 03.04.2024
Reviewed on 13.04.2024

AGRISCIENCE AND TECHNOLOGY
Armenian National Agrarian University
АГРОНАУКА И ТЕХНОЛОГИЯ
International Scientific Journal
ISSN 2579-2822

UDC 633.12(479.25) doi: 10.52276/25792822-2024.2-166

Risk Assessment of Toxic Elements in Buckwheat Produced in Armenia

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ARTICLE INFO

Keywords:
consumption,
daily intake,
dietary exposure,
heavy metal,
risk

ABSTRACT

Buckwheat provides essential nutrients crucial for the human body's regular functioning, however, studies have indicated that it may also contain potentially toxic elements. Therefore, this study aims to assess the health risks associated with buckwheat produced in Armenia, focusing on dietary exposure to toxic elements (lead, cadmium, and arsenic). Risk assessment was conducted using the margin of exposure (MOE) method, involving calculating daily intakes for toxic elements. The study findings suggest that the levels of toxic elements in the investigated buckwheat samples were within acceptable limits. This indicates that there is no significant health risk to consumers.

Introduction

Buckwheat, belonging to the Polygonaceae family, is classified as pseudocereals. Cultivated globally, it is commonly processed, particularly as a key ingredient in functional foods (Sofi, et al., 2023). Notably, buckwheat surpasses rice and legumes such as wheat and corn in nutritional profile. It contains essential nutrients like proteins, vitamins, and essential amino acids. Its well-balanced amino acid composition adds significant value to the human diet (Huang, et al., 2013). While the digestibility of buckwheat proteins is about 80 %, which is lower than animal proteins like hemoglobin and ovalbumin, it is higher than that of cereal proteins (e.g., sorghum 55-59 %, corn 66-75 %) and is comparable to the content found in rice bran (89 %) and wheat germ (77-93 %) (Džafić, et al., 2022). Moreover, buckwheat provides essential nutrients crucial for the human body's regular functioning, including vitamins, fatty acids, and trace elements. However, studies have highlighted the importance of considering that they may also contain potentially toxic elements such as heavy metals (Pipoyan, et al., 2022; Zhou, et al., 2016).

Heavy metals can pose various adverse health effects, including carcinogenic, mutagenic, teratogenic, and neurotoxic impacts (Zhang, et al., 2018). Furthermore, exposure to these elements through contaminated foods can lead to a weakened immune system and damage to the gastrointestinal tract, among other consequences. It is noteworthy that each metal possesses distinct physicochemical properties that play a vital role in determining toxicological mechanisms (Zhang, et al., 2018; EFSA, 2012). Among heavy metals, lead (*Pb*), cadmium (*Cd*), and arsenic (*As*) are known as toxic

elements, as exposure to even low levels can lead to public health issues. Lead has toxic effect on the central and peripheral nervous system, kidneys, cardiovascular system, gastrointestinal tract, and male reproductive system (EFSA 2010). Long-term exposure to high doses of cadmium can lead to teratogenesis, mutagenicity, and carcinogenesis (Zhou, et al., 2016). Long-term exposure to high doses of inorganic arsenic can lead to skin, lung, and bladder cancers (EFSA, 2009).

Notably, diet is one of the key sources of exposure to toxic elements for the population (Jolly, et al., 2013). As cereals and cereal-based products constitute a valuable component of the typical diet of the population, it is crucial to investigate the levels of toxic elements in these products and evaluate the potential health risks associated with dietary exposure. Additionally, it is important to note that in recent years, not only imported but also locally cultivated buckwheat has been sold on the markets and consumed by the population. Therefore, this study's objective is to assess the health risks associated with the consumption of buckwheat produced in Armenia. It focusing on dietary exposure to toxic elements: lead (*Pb*), cadmium (*Cd*), and arsenic (*As*).

Materials and methods

Sampling and analysis

Buckwheat sampling was conducted as part of the state monitoring program, from agricultural plots in six rural communities in the Gegharkunik and Aragatsotn regions. Sampling was carried out by standard operating procedures (SOPs) developed in the Centre for Ecological-Noosphere Studies (CENS) of the National Academy of Sciences of the Republic of Armenia, using the guidelines of Codex Alimentarius Commission (CAC, 1993) and recommendations of the ISO sampling standard (ISO 874-1980, 2017). Preparation and further chemical analysis of the samples was carried out at the Republican Center for Veterinary and Sanitary and Phytosanitary Laboratory Services, accredited according to ISO 17025 standard.

The buckwheat samples underwent standard preparation procedures, including washing and removal of non-edible particles. The samples were mixed and ground. For analysis, 0.5 g of each sample was taken, treated with 3.0 ml concentrated nitric acid and 0.5 ml hydrogen peroxide in specific tubes, and microwaved. After mineralization, the cooled tubes were vented, and the mineralized sample was degassed in an ultrasonic bath. The final step involved dilution of the mineralizer with deionized water to 10 ml. To detect lead (*Pb*), cadmium (*Cd*), and arsenic (*As*) in buckwheat, samples were analyzed using atomic absorption spectrometry (AAS, Thermo Fisher iCE-3500). To ensure quality, the Multi-Element Aqueous CRM US EPA 23 standard solution was employed. Each composite sample underwent a replicate analysis, with recovery ratios consistently ranging from 95 to 98.8 % during the analytical procedures.

Risk assessment

The daily intake of toxic elements (*Pb, As,* and *Cd*) through buckwheat consumption is estimated using the following formula (US EPA, 1997):

$$EDI = \frac{C * IR}{BW},$$

where *EDI* (mg/kg/day) represents the estimated daily intake of the toxic element via buckwheat consumption, *C* is the content (mg/kg) of the investigated element in buckwheat, and *BW* is the average body weight in kilograms (kg) for the population. *IR* is the average daily buckwheat consumption in kilograms per day (kg/day). According to data from the RA Statistical Committee, the daily consumption data on buckwheat in dry form is 10.9 g/day (ARMSTAT, 2021).

To assess the potential health risk to the population, the margin of exposure (MOE) for each toxic element was calculated using the following formula:

$$MOE = \frac{HBGV}{EDI},$$

where *HBGV* is the health-based guidance values of each investigated toxic element presented in Table 1.

Table 1. Health-based guidance values for toxic elements*

Element	HGBVS	Value (mg/kg/day)	Health impact	Reference
Pb	BMDL10	6.3E-04	Increased incidence of chronic kidney disease in adults	EFSA, 2010
As	BMDL01	3.0E-04	Skin, lung and bladder cancer	EFSA, 2009
Cd	TWI	2.5E-03	Renal failure	EFSA, 2011

Note: *BMDL - Benchmark Dose Lower Confidence Limit, TWI - Tolerable Weekly Intake.*

*Composed by the authors.

Results and discussions

Contents of toxic elements in buckwheat

Toxic elements lead (*Pb*), cadmium (*Cd*), and arsenic (*As*) were found in all buckwheat samples produced in RA (Table 2). The obtained results showed that *Pb, Cd,* and *As* contents in buckwheat were 0.02 mg/kg, 0.05 mg/kg, and 0.15 mg/kg, respectively. This did not exceed the maximum allowable limits (MAL) established by the EAEU Technical Regulation (TR CU 021/2011).

Table 2. Toxic element contents in buckwheat samples*

Mean/SD	*Pb*	*Cd*	*As*
Mean	0.02	0.05	0.02
±SD	0.003	0.004	0.01
MAL	0.2	0.15	0.25

Note: *MAL - maximum allowable limit.*

*Composed by the authors.

This study was compared with studies conducted in Armenia and other countries. In previous studies conducted in Armenia, heavy metals content was determined in samples of cereals sold in Yerevan, including buckwheat. Data from the study showed that higher concentrations of lead were found in samples of cooked buckwheat than in samples of other cereals, but they were within acceptable limits. However, the levels of lead and cadmium found in all cereal samples studied, including buckwheat, were far below(Pipoyan, et al., 2022).

According to another study conducted in the Ryazan region (Russia), buckwheat exhibits a high capacity for absorbing heavy metals. The analysis of the empirical series of heavy metal supply revealed that buckwheat absorbs cadmium from the soil more intensively than lead (Huang, et al., 2013). According to studies conducted in Bangladesh, the arsenic content cereals, especially in buckwheat, did not exceed the permissible level (Parvin, et al., 2021).

Exposure assessment and risk characterization

The estimated daily intake (EDI) of the investigated toxic elements due to buckwheat consumption is illustrated in Figure 1. Among the studied elements, cadmium had the highest average daily intake at 4.84E-06 mg/kg/day, followed by lead (Pb) at 2.25E-06 mg/kg/day and arsenic at 1.65E-06 mg/kg/day, respectively.

The obtained EDI values (Figure 1) of toxic elements did not exceed the established HBGVs (Table 1).

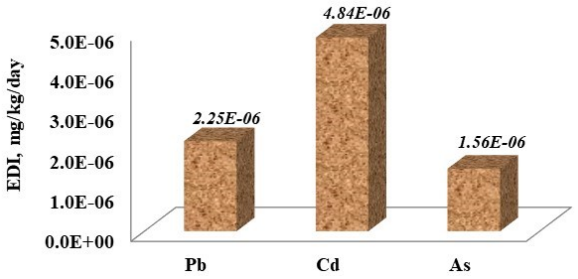

Figure 1. Estimated daily intake (EDI) of toxic elements via buckwheat consumption *(composed by the authors).*

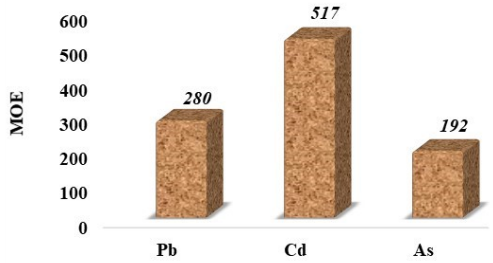

Figure 2. Estimated daily intake (EDI) of toxic elements via buckwheat consumption *(composed by the authors).*

To gain a better understanding of the health risks associated with toxic elements in buckwheat, the margin of exposure (MOE) was calculated based on health-based guidance values (HGBVs). Following the methodology recommended by the European Food Safety Authority (EFSA), if the MOE values exceed 10 (MOE>10), there is no risk to public health. For all toxic elements detected in samples of the investigated buckwheat, the MOE results (Figure 2) were significantly higher than 10, indicating that the detected contents of toxic elements do not present a health risk to the population.

It is essential to note that this study presents risk assessment results concerning dry, non-culinary processed buckwheat produced in Armenia. In contrast, previous studies in Armenia were performed using the total diet

study (TDS) approach, where all buckwheat samples were treated according to culinary recipes. In a previous study in Armenia (Pipoyan and Beglaryan, 2019), an assessment of the carcinogenic and non-carcinogenic risks associated with exposure to heavy metals from imported buckwheat consumption was conducted. The calculated results, expressed as Target Hazard Quotients (THQ), were consistently below 1 (THQ<1). According to established criteria THQ values below 1 are acceptable and pose no risk to human health. The results obtained indicated no significant health risks associated with heavy metal exposure from buckwheat for both men and women. Although higher lead concentrations were detected in buckwheat samples than other cereals, these concentrations remained within acceptable limits. It is noteworthy that the levels of lead and cadmium in all buckwheat samples were below the established acceptable levels. These findings assure that buckwheat consumption, even with higher lead concentrations, does not pose a health risk based on the applied assessment method.

Conclusion

This study assessed the possible health risks associated with the ingestion of toxic elements, namely lead (*Pb*), cadmium (*Cd*), and arsenic (*As*), detected in buckwheat cultivated in Armenia. Considering average buckwheat consumption, dietary exposure to the studied toxic elements (*Pb, Cd,* and *As*) did not pose potential health risks.

In comparing these results with our previous studies, it is crucial to highlight that, despite the high consumption of imported buckwheat in Armenia, no contribution to the health risks of toxic elements was identified in the case of locally grown buckwheat. However, regular assessments are needed continuously to ensure the safety of buckwheat consumption, especially considering its susceptibility to accumulating toxic elements from the environment.

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Declarations of interest

The authors declare no conflict of interest concerning the research, authorship, and/or publication of this article.

Accepted on 20.03.2024
Reviewed on 26.04.2024