AGRISCIENCE AND TECHNOLOGY
ARMENIAN NATIONAL AGRARIAN UNIVERSITY

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АГРОНАУКА И ТЕХНОЛОГИЯ
НАЦИОНАЛЬНЫЙ АГРАРНЫЙ УНИВЕРСИТЕТ АРМЕНИИ

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Հայաստանի ազգային ագրարային համալսարան

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Software Package for Determining the Capillary Adsorption Potential in Irrigated Lands

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ABSTRACT

In the current work, an analytical formula for determining the capillary adsorption potential (CAP) has been derived as a result of solving the moisture transfer equation. A universal software package program has been written in the Python language. The code enables to compute the values of CAP at any soil depth and at any time of irrigation for various soil parameters. To illustrate the code, the results of some numerical calculations are presented at the end of the work.

Introduction

Forecasting of capillary adsorption potential (CAP) in irrigated lands plays a specific role in hydromelioration. Optimal management of the water regime in irrigated lands ensures increase in crop yield capacity and improvement in fertility. CAP depends on various physicochemical parameters and mechanical characteristics of the soil. Therefore, the creation of a software package for predicting CAP in various types of lands with different soil parameters is of vital significance (Yeghiazaryan, 2006).

In the current work, the analytical formula for determining the CAP was obtained as a result of solving model equation of moisture transfer in the aeration zone. A universal software package is suggested to identify values of CAP for arbitrary soil parameters. The software package is written in Python language (https://ru.wikipedia.org/wiki/Python),

which enables to compute values of CAP at any soil depth and at any time during the period of irrigation interval for different values of soil parameters. By using the code, it is possible to depict the dependence of the CAP on the depth of the soil, as well as its surface as a function of $\varphi\ (x,\ t)$ with two variables: the depth of the soil and the period of irrigation interval.

Materials and methods

The distribution of CAP via depth of soil and time of irrigation is described by the following moisture transfer equation (Tikhonov and Samarsky, 1977):

$$\frac{\partial \varphi}{\partial t} = a^2 \frac{\partial^2 \varphi}{\partial^2 x} - a_1. \qquad (1)$$

Here $\varphi\ (x,\ t)$ is the required CAP:

$$a^2 = \frac{K_0}{\theta_0}, \quad a_1 = \frac{e_0}{\theta_0}, \tag{2}$$

where K_0 - is the mean value of soil moisture transfer coefficient, θ_0 - is the average value of differential moisture capacity, e_0 - is the absorption intensity of moisture by plant roots.

The equation (1) is supplemented with the boundary and initial conditions:

$$\frac{\partial\varphi}{\partial x}\bigg|_{x=0} = \overline{q}_1 \quad \frac{\partial\varphi}{\partial x}\bigg|_{x=l} = \overline{q}_2, \tag{3}$$

$$\varphi(x,0)=q(x). \tag{4}$$

Here $\overline{q}_1$ and $\overline{q}_2$ are average velocities of moisture conductivity above and below ground surfaces respectively, $q(x)$ is the capillary adsorption potential when $t=0$. It leads to the following representation:

$$q(x)=\alpha e^{-\beta x}, \tag{5}$$

where α and β are known numerical parameters, which are determined experimentally. It should be noted that experimental data are well approximated with the representation (5).

Making similar reasoning as when constructing a solution to the classical initial-boundary value problem for the moisture transfer equation, one can make it sure that the solution to problems (1), (3), (4) admits the following form:

$$\varphi(x,t) = \frac{\left(\overline{q}_2 - \overline{q}_1\right)x^2}{2l} + \overline{q}_1 x + \frac{C_0}{2} +$$
$$+ \sum_{n=1}^{\infty} C_n \cos\frac{\pi n}{l} x e^{-\left(\frac{a\pi n}{l}\right)^2 t} + W_0 t, \tag{6}$$

where Fourier coefficients C_0 and C_n are equal to:

$$C_0 = \frac{2}{l}\int_0^l \psi(x)dx, \tag{7}$$

$$C_n = \frac{2}{l}\int_0^l \psi(x)\cos\frac{\pi n}{l} xdx, \tag{8}$$

where

$$\psi(x) = q(x) - \frac{\left(\overline{q}_2 - \overline{q}_1\right)x^2}{2l} - q_1 x, \tag{9}$$

$$W_0 = \frac{2a^2\left(\overline{q}_2 - \overline{q}_1\right)}{l} - 2a_1 = 2\left(\frac{a^2\left(\overline{q}_2 - \overline{q}_1\right)}{l} - a_1\right). \tag{10}$$

Placing (10) in (8) and (9) with the consideration of (5), and using the values of the following integrals:

$$\int_0^l e^{-\beta x}\cos\frac{\pi n}{l} xdx = \begin{cases} \dfrac{\beta l^2\left(1+e^{-\beta l}\right)}{\pi^2 n^2 + \beta^2 l^2}, & \text{if } n=2k+1, \\[3mm] \dfrac{\beta l^2\left(1-e^{-\beta l}\right)}{\pi^2 n^2 + \beta^2 l^2}, & \text{if } n=2k. \end{cases}$$

$$\int_0^l x^2\cos\frac{\pi n}{l} xdx = \begin{cases} -\dfrac{2l^3}{\pi^2 n^2}, & \text{if } n=2k+1, \\[3mm] \dfrac{2l^3}{\pi^2 n^2}, & \text{if } n=2k. \end{cases} \quad n \neq 0$$

$$\int_0^l x\cos\frac{\pi n}{l} xdx = \begin{cases} -\dfrac{2l^2}{\pi^2 n^2}, & \text{if } n=2k+1, \\[3mm] 0, & \text{if } n=2k. \end{cases} \quad n \neq 0$$

we get the following for the Fourier coefficients:

$$C_0 = \begin{cases} \dfrac{2a}{\beta l}\left(1-e^{-\beta l}\right) - \dfrac{l}{3}\left(\overline{q}_2 + 2\overline{q}_1\right), & \text{if } n=0, \beta \neq 0, \\[3mm] 2a - \dfrac{l}{3}\left(\overline{q}_2 + 2\overline{q}_1\right) & \text{if } n=0,\ \beta=0. \end{cases} \tag{11}$$

$$C_n = \begin{cases} \dfrac{-2l\left(\overline{q}_2 - \overline{q}_1\right)}{\pi^2 n^2} + \dfrac{2\beta la\left(1-e^{-\beta l}\right)}{\pi^2 n^2 + \beta^2 l^2}, & \text{if } n=2k+1, \\[3mm] \dfrac{2l\left(\overline{q}_2 + \overline{q}_1\right)}{\pi^2 n^2} + \dfrac{2\beta la\left(1+e^{-\beta l}\right)}{\pi^2 n^2 + \beta^2 l^2}, & \text{if } n=2k. \end{cases} \tag{12}$$

Results and discussions

First of all, we should specify the ranges of variation for the following basic parameters depending on the soil type:

1. Soil depth, $0 \leq x \leq l$ (м)

2. Period of irrigation interval $0 \leq t \leq T$ (day)

3. Average velocity of water exchange on the soil surface $\overline{q}_1$ (m/day)

4. Average velocity of water exchange under the soil surface $\overline{q}_2$ (m/day)

5. Parameters of CAP at the initial time period a (m) and β (1/m) $t=0$

6. Parameter application intervals a^2 (m^2/day) and a_1 (m/day).

Now we will shortly describe the code implementation. Let's enter starting parameters:

$$l,\ t,\ \alpha,\ \beta,\ \overline{q}_1,\ \overline{q}_2\ a_1,\ a^2.$$

Then the Python code computes coefficients of Fourier C_0 and C_n in accordance with the formula (11) and (12). As a final step the code computes the values of capillary adsorption potential (CAP) $\varphi(x,t)$, designs surface $\varphi(x,t)$ as a function with two variables, as well as the CAP dependence on depth of soil at different period of irrigation intervals is computed by using the formula (6).

Below, the results for some numerical calculations are introduced.

Figure 1.1, 1.2 and Table 1 correspond to the following values of the main parameters:

$$l=1\ m,\ T=2\ day,\ \overline{q}_1=-1\ m/day,\ \overline{q}_2=-0.5\ m/day,$$
$$a_1=0.3\ m/day,\ a^2=0.25\ m^2/day,$$
$$\alpha=4\ m,\ \beta=1\ 1/m.$$

Table 1. The value of the capillary adsorption potential $\varphi(x,t)$ at various values of x and t*

N	x	t	$\varphi(x,0)$
1	0.0	0.0	3.9993921772309675
2	0.1	0.2	3.2479608008492193
3	0.2	0.4	2.94178222304284
4	0.3	0.6	2.757037162850827
5	0.4	0.8	2.6573340811101973
6	0.5	1.0	2.6159797040328328
7	0.6	1.2	2.6139960682039005
8	0.7	1.4	2.63916068818068
9	0.8	1.6	2.684347466635085
10	0.9	1.8	2.7458379447159325
11	1	2.0	2.821970456452652

*Composed by the author.
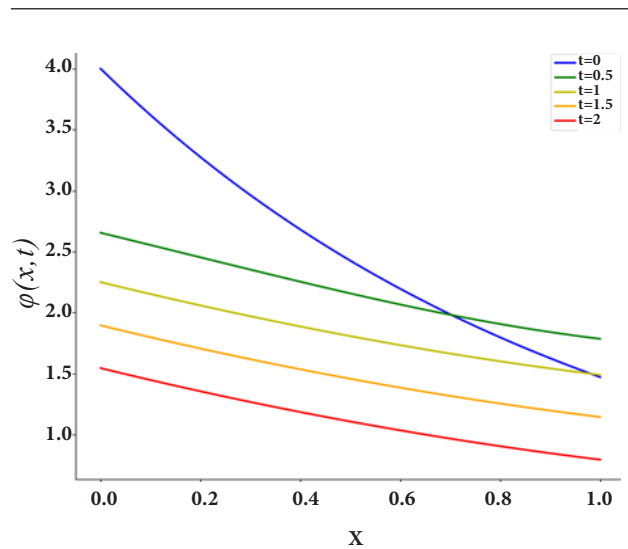
Figure 1.1. Dependence of the capillary adsorption potential on the soil depth at different values of *t (composed by the author).*
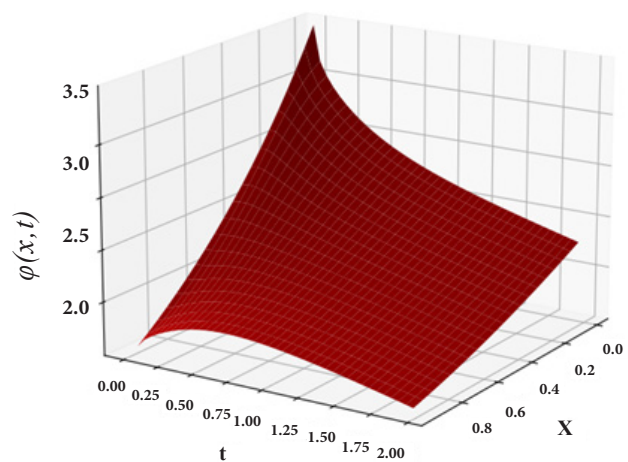
Figure 1.2. Two-dimensional distribution of the capillary adsorption potential *(composed by the author).*

Figure 2.1, 2.2 and Table 2 correspond to the following values of the main parameters:

$$l=0.1\ m,\ T=2\ day,$$
$$\overline{q}_1=-0.5\ m/day,\ \overline{q}_2=-0.5\ m/day,$$
$$a_1=0.3\ m/day,\ a^2=0.25\ m^2/day,$$
$$\alpha=4\ m,\ \beta=0\ 1/m.$$

Table 2. The value of the capillary adsorption potential $\varphi(x,t)$ at various values of x and t *

N	x	t	$\varphi(x,0)$
1	0.0	0.0	4.000010132114987
2	0.1	2.0	2.7750000000000004

*Composed by the author.

Figure 3.1, 3.2 and Table 3 correspond to the following values of the main parameters:

$$l=0.5 \text{ m}, \ T=2 \text{ day},$$
$$\bar{q}_1 = -0.75 \text{ m/day}, \ \bar{q}_2 = -0.5 \text{ m/day},$$
$$a_1=0.3 \text{ m/day}, \ a^2=0.25 \text{ m}^2\text{/day},$$
$$\alpha=4 \text{ m}, \ \beta=0.5 \text{ 1/m}.$$
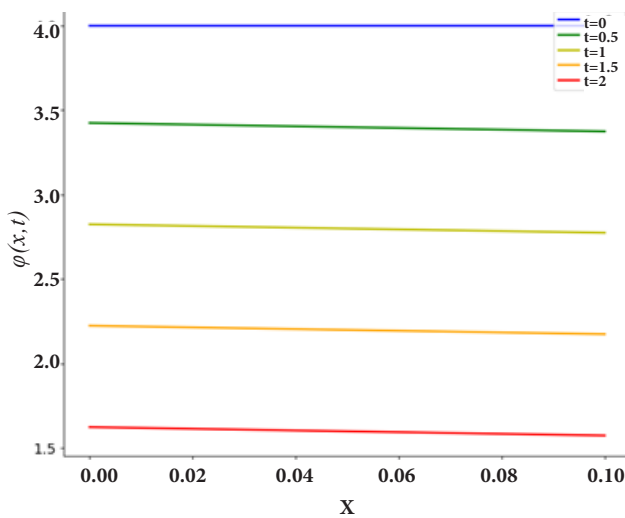
Figure 2.1. Dependence of the capillary adsorption potential on the soil depth at different values of *t (composed by the author)*.

Table 3. The value of the capillary adsorption potential $\varphi(x,t)$ at various values of x and t *

N	x	t	$\varphi(x,0)$
1	0.0	0.0	3.999873358300363
2	0.1	0.4	3.496968727287925
3	0.2	0.8	3.285880778971651
4	0.3	1.2	3.0833536234427483
5	0.4	1.6	2.8858541115536283
6	0.5	2.0	2.693354136904751

*Composed by the author.
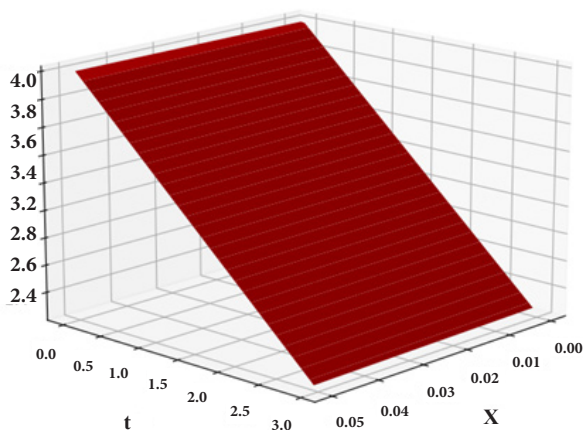
Figure 2.2. Two-dimensional distribution of the capillary adsorption potential *(composed by the author)*.
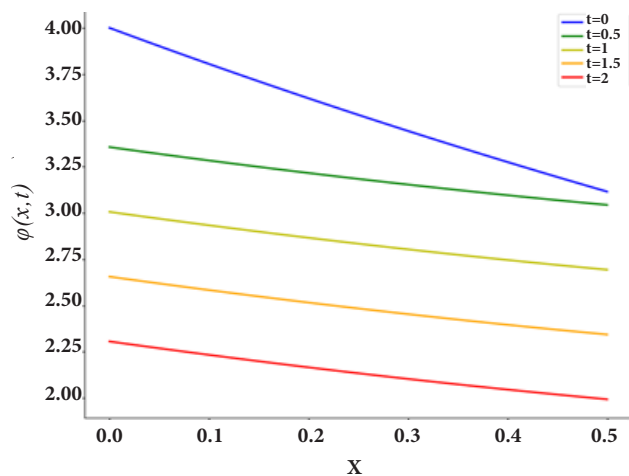
Figure 3.1. Dependence of the capillary adsorption potential on the soil depth at different values of *t (composed by the author)*.
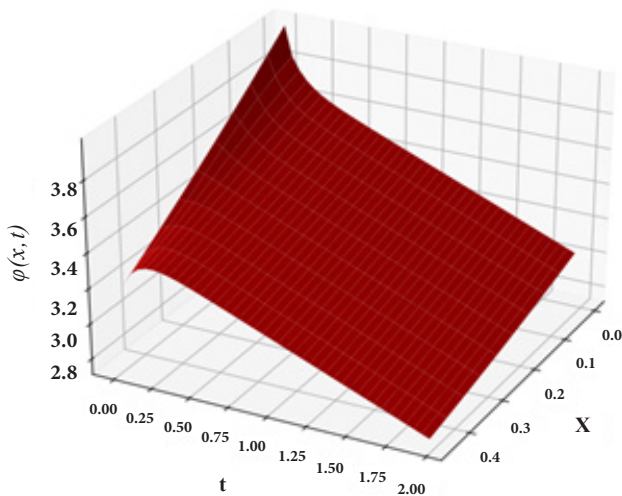
Figure 3.2. Two-dimensional distribution of the capillary adsorption potential *(composed by the author)*.

Conclusion

An analytical-numerical method for determining the capillary adsorption potential (CAP) in irrigated lands is recommended in the current work. Software package program written in Python language has been designed. The code enables to estimate CAP depending on depth of soil and period of irrigation for different parameters of the soil. After entering the initial parameters the code computes the values of CAP as well as depicts two dimensional distributions of CAP.

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Studying the Reclamation State of the Irrigated Meadow Brown Lands in Araksavan Community of Ararat Region

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A R T I C L E   I N F O

A B S T R A C T

Improvement of land reclamation methods and ecological state of the soils is essential for the sustainable development of agriculture in Armenia. The aim of the current work is to study the chemical composition of the irrigated meadow-brown soils with an area of 25 hectares in the village of Araksavan.

The results of the study showed that this land plot is not homogeneous in chemical composition. The studied soils are saline and alkaline, and without any chemical reclamation it is impossible to use them in agriculture. Thus, it is recommended to conduct chemical reclamation activities in the mentioned land area.

Introduction

Improvement of the soils' reclamation state is important for the sustainable development of agriculture in Armenia. The study of negative processes occurring in the lands and the development of preventing measures are global issues the solution of which is determinant for ensuring population with necessary food product.

The solution to these problems has become more complicated over the past period due to global climate warming and improper human economic activity, as a result of which a decrease in crop yield capacity, as well as problems related to the food quality and human health are recorded. Among these negative processes, salinization and alkalinization of lands can be distinguished, which

have dynamic nature, and there is a need for continuous research in order to identify the intensity of their development.

Materials and methods

Experimental plots with 25 ha land area located in the Araksavan community of the Ararat region have served as a study object. The research has been conducted through field and laboratory methods. 9 soil sections were cut on the specified land plot and soil samples were taken at the depth of 0-30, 30-60, 60-100 cm layers from each section to conduct laboratory research.

The soil chemical composition (pH), total amount of

water-soluble salts, the content of adsorbing complex, the ratio of cations and fluctuations of groundwater level have been studied per months during the year. The studies were conducted in field and laboratory conditions. The chemical composition of the water extract was determined and the general chemical analysis was conducted through the adopted methods (Arinushkina, 1962), pH was determined via electrode potentiometric method, exchangeable Ca and Mg – with the method of A.N. Baghramyan and A.A. Abrahamyan, absorption capacity - according to Gedroits method (Gedroits,1929).

Results and discussions

The results of the laboratory study showed that in the above-noted area at the sections of 1, 2 and 3 the lands are not salinized, pH ranges from 7.5-7.9, the water-soluble salts do not exceed 0.132 %, the CO_3^{2-} toxic ion is absent in a meter layer (Table 1). While the results of the chemical composition in the land sections of 4, 5, 6, 7, 8 and 9 show that in a meter layer the soils are highly alkaline, pH fluctuates within the range of 9.5-9.7; they are also averagely salinized and the total amount of water-soluble salts is 0.283-0.500 %. There is a toxic ion CO_3^{2-} in the medium, the alkaline hydrolysis of which is responsible for the alkaline reaction of the soil solution. The amount of water-soluble Na is also higher than the maximum permissible limit (the permissible amount of water-soluble Na is 0.75 mg-eq/100 g).

Thus, from the study results (Table 1), it becomes obvious that the soils taken from the mentioned sections are saline-alkaline, the medium contains Na_2CO_3, without the removal of which it is impossible to cultivate crops in the mentioned lands.

The content and ratio of the soil absorbing complex has been also studied, the data of which are presented in Table 2.

Table 1. The chemical composition of the irrigated meadow soils*

Section, n/n	Depth, cm	pH	Salts, %	Water-soluble ions, mg-eq/100g soil						
				CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	$Na^+ + K^+$
1	0-30	7.7	0.111	-	1.00	0.20	0.28	0.35	0.32	0.81
	30-50	7.8	0.105	-	1.00	0.31	0.10	0.35	0.24	0.82
	50-100	7.9	0.126	-	1.20	0.11	0.35	0.25	0.48	0.93
2	0-30	7.8	0.132	-	1.11	0.51	0.21	0.55	0.40	0.88
	30-50	7.7	0.126	-	1.03	0.45	0.25	0.45	0.32	0.96
	50-100	7.6	0.116	-	1.00	0.45	0.21	0.65	0.48	0.53
3	0-30	7.5	0.103	-	0.97	0.28	0.17	0.55	0.40	0.47
	30-50	7.6	0.109	-	1.00	0.31	0.22	0.55	0.48	0.50
	50-100	7.6	0.108	-	1.00	0.37	0.19	0.50	0.40	0.66
4	0-30	9.7	0.432	3.59	4.20	0.73	0.56	0.50	0.16	4.83
	30-50	9.5	0.500	3.21	4.81	0.99	0.58	0.30	0.16	5.92
	50-100	9.2	0.458	2.40	4.12	0.99	0.82	0.25	0.24	5.44
5	0-30	9.3	0.437	2.27	4.25	0.76	0.58	0.55	0.32	4.72
	30-50	9.2	0.439	2.27	4.33	0.85	0.44	0.45	0.32	4.85
	50-100	9.7	0.477	2.79	3.53	2.00	0.92	0.30	0.08	6.07
6	0-30	9.4	0.449	0.93	3.53	1.80	0.90	0.30	0.32	5.61
	30-50	9.5	0.333	2.00	2.72	1.21	0.52	0.30	0.24	3.91
	50-100	9.1	0.328	1.94	2.64	1.21	0.57	0.40	0.32	3.70
7	0-30	9.1	0.359	1.77	2.72	1.27	0.88	0.50	0.40	3.97
	30-50	8.6	0.336	1.84	2.80	1.27	0.49	0.30	0.32	3.94
	50-100	8.6	0.283	1.67	2.20	1.04	0.71	0.40	0.32	3.23
8	0-30	8.5	0.294	1.90	2.36	1.61	0.50	0.50	0.48	3.49
	30-50	8.8	0.397	2.00	2.84	1.5	0.90	0.40	0.32	4.77
	50-100	8.8	0.394	2.00	2.76	1.75	0.88	0.50	0.32	4.57
9	0-30	8.9	0.391	1.24	2.64	1.92	0.86	0.40	0.32	4.70
	30-50	9.2	0.446	2.17	3.80	1.52	0.62	0.40	0.46	5.38
	50-100	9.4	0.478	3.13	4.00	1.61	0.60	0.55	0.48	5.18

*Composed by the authors.

Table 2. The composition of absorbed cations*

Section, n/n	Depth, cm	Absorbed cations, mg-eq per 100 g soil				Total, mg-eq/100 g soil	Absorbed cations, %			
		Ca	*Mg*	*Na*	*K*		*Ca*	*Mg*	*Na*	*K*
1	0-30	25.6	18.7	1.00	1.1	46.4	55.2	40.3	2.1	2.4
	30-50	22.1	18.8	2.1	1.1	44.1	50.1	42.6	4.8	2.5
	50-100	23.1	20.0	1.5	1.1	45.7	50.5	43.8	3.3	2.4
2	0-30	22.4	19.6	1.9	1.3	45.2	49.6	43.4	4.2	2.8
	30-50	23.7	20.08	2.0	1.0	46.8	50.6	43.0	4.3	2.1
	50-100	23.0	21.02	2.0	1.8	47.8	48.1	43.9	4.2	3.8
3	0-30	22.4	20.0	1.6	1.6	45.6	49.1	43.9	3.5	3.5
	30-50	21.9	19.6	1.3	1.1	43.9	50.0	44.6	2.9	2.5
	50-100	20.3	21.1	1.5	1.1	44.0	46.1	48.0	3.4	2.5
4	0-30	12.5	9.2	13.1	0.8	35.6	35.1	25.8	36.9	2.2
	30-50	15.0	7.4	13.5	1.1	37.0	40.5	20.0	36.5	3.0
	50-100	13.0	6.1	13.0	1.2	33.3	39.0	18.4	39.0	3.6
5	0-30	13.3	8.5	7.2	1.2	30.2	44.4	28.1	23.8	4.0
	30-50	12.5	7.4	11.6	1.4	32.9	41.1	24.3	35.2	4.2
	50-100	12.5	7.4	9.4	0.8	30.1	41.4	24.7	31.4	2.5
6	0-30	13.3	5.2	12.1	1.0	31.6	42.0	16.5	38.3	3.2
	30-50	13.7	5.6	12.3	1.2	32.8	41.8	17.1	37.5	3.6
	50-100	13.1	5.1	11.4	1.0	30.6	42.8	16.7	37.2	3.3
7	0-30	14.6	9.0	8.6	0.9	33.1	44.1	27.1	26.0	2.8
	30-50	12.1	8.8	8.4	0.6	29.9	40.5	29.3	28.2	2.0
	50-100	13.4	7.4	11.9	1.0	33.7	39.7	22.0	35.3	3.0
8	0-30	13.7	5.6	12.0	1.1	32.4	42.2	17.3	37.1	3.4
	30-50	13.9	6.7	11.0	1.1	32.7	42.6	20.4	33.8	3.2
	50-100	15.3	6.2	9.4	0.9	31.8	48.1	19.5	29.5	2.9
9	0-30	18.3	6.1	10.7	1.3	36.4	50.2	16.8	29.5	3.5
	30-50	15.4	5.6	9.2	1.1	31.3	49.2	17.9	29.3	3.6
	50-100	16.1	6.3	9.4	1.3	33.1	48.6	19.0	28.4	4.0

*Composed by the authors.

In the soil sections of 1, 2 and 3 the amount of *Ca* dominates in the content of exchangeable cations, which makes 60 % of the total exchangeable cations, but the amount of absorbed Mg is higher than the maximum permissible limit (the permissible limit of absorbed *Mg* is up to 30 %), while the amounts of absorbed *Na* and *K* are within the permissible limits (> 5 %).

Thus, in the specified sections the soils are characterized by the ratio of exchange cations unfavorable for crops growth and development, which can be improved by reducing the amount of Mg absorbed (Papinyan, 1977). In

case of such ratio of absorbing complex, the crop yield capacity declines.

In the sections of 4, 5, 6, 7, 8 and 9 the amount of absorbed *Na* predominates in the content of absorbing complex, ranging from 7.2-13.5 mg-eq (the permissible amount of absorbed Na is 2.25 mg-eq), which makes 23.8-36.5 % of the total amount of absorbed cations.

The data on the groundwater level received throughout 2020 for the studied area of Araksavan community are introduced in Table 3.

Table 3. The mean indicators of groundwater levels*

Location	February	March	April	May	June	July	August	September	October	November	December	2020 annual, m
Araksavan	1.7	1.47	1.75	1.57	1.47	1.87	2.13	1.83	1.76	1.83	1.72	1.74

*Composed by the authors.

To estimate the fluctuations of groundwater levels a diagram has been also designed (Figure).
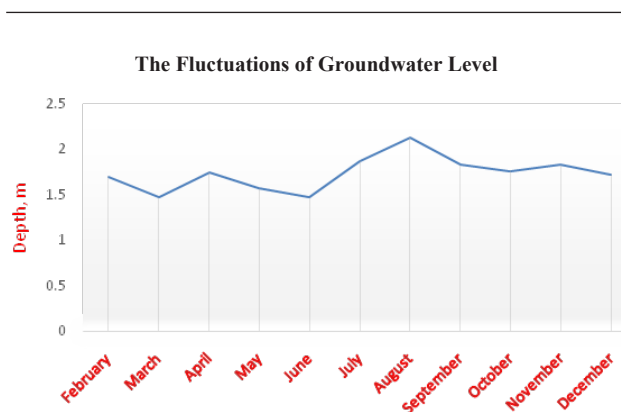
Figure. Diagram for groundwater level fluctuations *(composed by the authors).*

As the diagram shows, the groundwater level is quite high, as a result of which salinization processes are observed. In the spring months, its level mainly rises up to 1.47 m, and from July it begins to decrease due to climate warming, increase of the use rates of deep waters, etc. It reached its lowest level in August (2.13 m). Groundwater levels fluctuate very little during the autumn months (almost unchanged).

The average annual depth is 1.74 m. Groundwater level fluctuations during the year make about 0.66 m.

Conclusion

Thus, upon the laboratory and field research studies conducted along the 25 ha experimental plot of the Araksavan community, it can be concluded that the ratio of exchange cations in the sections of 1, 2 and 3 is not favorable for the growth and development of crops. Thus, to improve the situation, it is recommended to use *Ca* containing compounds. Besides, in the sections of 4, 5, 6, 7, 8 and 9 it is necessary to implement chemical reclamation, otherwise it will be impossible to cultivate crops.

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Efficiency of Drip Irrigation in Intensive Orchards

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A R T I C L E   I N F O

A B S T R A C T

Technical and economic efficiency of the drip irrigation for intensive orchards has been justified by the example of Nor Artamet community in the Kotayk region. The working principle of drip irrigation system, its performance indices, as well as crops irrigation regime applied in the intensive orchards has been investigated and collated with the same indices recorded in the traditional orchards irrigated through surface irrigation method.

It has been proved that the vegetation period in the intensive orchards cultivated through drip irrigation is distinguished by high economic indices and profitability.

Thus, the latest irrigation technologies definitely ensure development of intensive agriculture.

Introduction

Currently, there is a huge amount of theoretical and experimental research results related to the efficiency of the contemporary irrigation technologies (drip, subsoil, rain irrigation), which have still some shortcomings from the prospect of problem interpretation and generalization of the received results (Shavlinskiy, et al., 2003, Yeghiazaryan, et al., 2014, Ghazinyan and Navoyan, 2015). These shortcomings are related to a number of circumstances, which come forth in the result of soil, climatic and economic conditions. The conducted investigations prove that the latest irrigation technologies provide much higher irrigation efficiency than surface irrigation (Kucher, 2016, Vodyanitskiy and Rastorguev, 2002, Yeghiazaryan, 2002, Yeghiazaryan and Miroyan, 2020). The high economic efficiency of the new irrigation technologies, ease of irrigation system exploitation and the increase of land use efficiency indicate that as a main technology, the drip irrigation is still second to none from the prospect of irrigated agriculture (Badtieva, et al., 2015).

The aim of the current research is to examine and justify the technical and economic efficiency of drip irrigation in the intensive orchards by the example of Nor Artamet community in the Kotayk region.
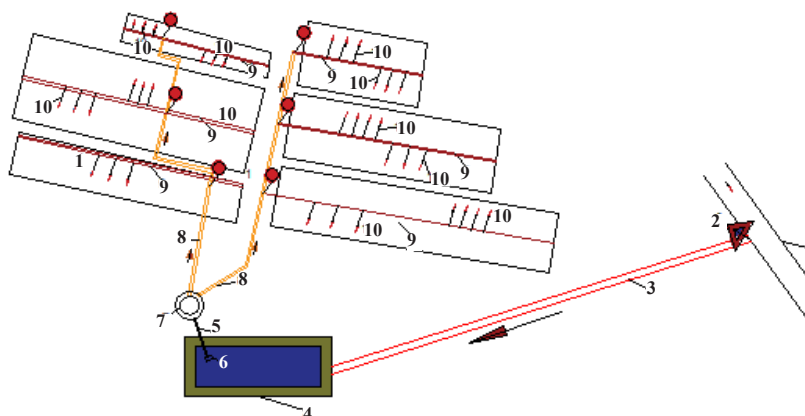
Figure 1. The plan of drip irrigation for an intensive orchard. *1-irrigation water source, 2-water-intake facility, 3-main self-pressure pipeline, 4-daily regulated basin, 5-absorption pipe, 6-receiver network of absorption pipe with reversing valve, 7-pumping station, 8-separator pipelines, 9-field pipes, 10-irrigation pipes, row direction (composed by the author).*

Materials and methods

Intensive apple orchards with 40 ha land area allocated throughout Nor Artamet community in the RA Kotayk region have been chosen as a study object. Drip irrigation system was applied for the cultivation of these orchards. The latter is installed in 6 land plots, the area of which fluctuates within the range of 2.4-11 ha land area. The intensive orchard is supplied with the irrigation water from the "Arzni-Shamiram" canal in a mechanical way. About 150 apple trees with "M-9" root cutting from the apple varieties Golden, Jonagold, Elstar, Gala, Granny Smith and Idared were planted in the orchard.

The main reason for applying the apple tree varieties with "M-9" root system in the orchards of this zone of the republic is that their root system spreads averagely at 50 cm depth and width in the soil layer. The life span of these tree varieties is about 10-15 years.

The main source of irrigation water in this region is the "Arzni-Shamiram" canal from where ($H_f = 5$ m) water is pumped through the pipe of 300 mm diameter in a mechanical way (with a pump of 55 kWT power and 90 l/s productivity) for the irrigation of about 80 ha land area, out of which 50 ha is irrigated through drip irrigation method. Irrigation water of the investigated land site is supplied through the pipe of 150 mm diameter, which conveys water into the daily regulated basin with 800 m³ volume. The depth of the basin makes 5 m and its area is 1600 m².

After passing through the sand, gravel and disc filters, the water of the basin is pumped out towards the orchard sites through 4 pumps. The power of each pump is 7.5 kWT.

The plan of drip irrigation network for the studied orchard area is introduced in Figure 1.

Results and discussions

The climate of the examined land site is described according to the data of hydro-meteorological station in Yeghvard. It is located at the altitude of 1336 m above sea level. The data retrieved within 2015-2019 show that the atmospheric precipitations make 329-468 mm, out of which 192-225 mm fell during the vegetation period. Based on the data of hydro-meteorological station the estimated crops evapotranspiration has been calculated and the atmospheric precipitations have been assessed per years (Figure 2).
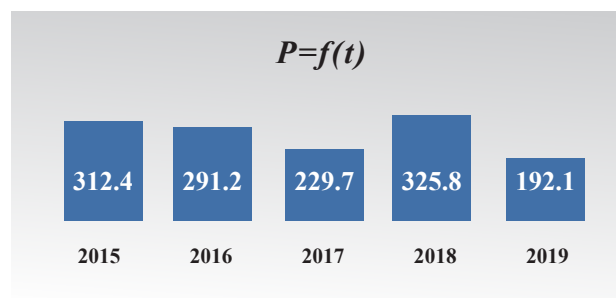
Figure 2 (a). Dynamics of estimated maximum evapotranspiration during the vegetation period; distribution of atmospheric precipitations per years
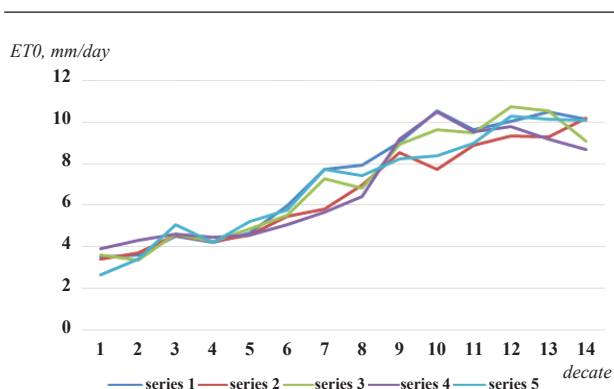
Figure 2 (b). Dynamics of estimated maximum evapotranspiration during the vegetation period; estimated maximum crops water demand *(composed by the author)*.

The conducted computations indicate that the moisture supply coefficient in the investigated area fluctuates within the range of 0.18-0.31. The three-year field studies show that the pressure at the initial part of the right sector in the first pumping unit makes 5.6 atm, in the filter it is 4.2 atm and at the end portion it makes 3.2 atm.

This means that the losses of water pressure in the right sector makes 2.4 atm. In the initial part of the left sector in the second pumping unit the pressure makes 3 atm, in the filter it accounts for 2.8 atm and at the end part it is 2.6 atm; hence, the pressure losses make 0.6 atm.

In case of simultaneous work of the pump units, 6-7 ha land area is irrigated which lasts about 6.1 hours. The inter-tree distance makes 70-100 cm. The diameter of watering pipes is 18 mm, which are installed 50 cm high above the ground level. The distance between the drippers makes 50 cm, water consumption per a dripper amounts to 2.5-3 l/hour. The irrigation time for each tree makes 2-3 hours, and 5-9 l water is supplied for each irrigation process. Drip irrigation system works uninterruptedly; 1100 m^3 water is supplied to 40 ha land area (27.5 m^3 per 1 ha land area).

The irrigation season starts in the first decade of May and ends within the last ten days of September, except for some tree varieties, the irrigation period of which ends up in the last ten days of October.

In the result of field studies, it has been found out that depending on the climate conditions, the irrigation rate fluctuates within the range of 4545-5060 m^3/ha and water use coefficient makes 5.4-7.5 m^3/c. It is worth mentioning that in case of implementing surface irrigation in the

traditional orchards the same coefficient varies within 35-38 m^3/c in conditions of 200 c/ha maximum yield capacity. It turns out that water consumption index in conditions of drip irrigation implemented in intensive orchards is reduced 6-7 times as compared to that of recorded in case of surface irrigation. This circumstance exerts a significantly favorable effect on other economic indices of intensive orchards. The calculations have been conducted for the evaluation of economic efficiency of drip irrigation system applied in the intensive orchards, and as a result, it has been disclosed that the annual production costs make about 1 mln/ha, the gross product value - 23.437 mln AMD/ha and the net income - 22.43 mln AMD/ha.

The analyses of technical and economic indices have shown that among the production costs of the investigated land site the electricity cost makes 121 thousand AMD/ha, fertilization and treatment costs make averagely 500 thousand AMD/ha, while the cost of yield sale fluctuates within 27-30 thousand AMD/c. The purchase period with the capital investments makes 2-3 years. For comparison it should be mentioned, that in case of surface irrigation under the same community conditions the production costs make 954 thousand AMD/ha, the net income makes 906 thousand AMD/ha, water consumption coefficient - 90 m^3/c and the gross rate of irrigation makes 6600 m^3/ha (Handbook, 2007).

Conclusion

The analyses of technical and economic efficiency index for the drip irrigation of intensive orchards by the example of Nor Artamet community of the Kotayk region disclose that watering rate amounts to 27.5 m^3/ha, irrigation rate - 5060 m^3/ha and the water consumption coefficient makes 5.4 m^3/c. It has been justified that water use coefficient in conditions of drip irrigation implemented in the intensive orchards is reduced in about 6-7 times as compared to the same indicator recorded in case of surface irrigation. The purchase period with capital investments is 2-3 years.

It has been proved that the intensive orchards, where drip irrigation is applied, provide high economic indices and profitability in vegetation period. It has been also asserted that the latest irrigation technologies are almost unrivaled in conditions of the current land relations and climate change and hence, ensure full opportunity to establish highly efficient intensive agriculture.

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The Dynamics of Winter Wheat Production and Analysis of the Main Affecting Factors in the Regions of the RA in 1991-2020

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ABSTRACT

The main goal of the current research is to study development tendencies of winter wheat production in the period of 1991-2020 and to examine the effect of the changes in cropland areas and yield capacity per hectare on the gross yield of winter wheat in separate periods. In 1991-2005, the gross yield demonstrated extensive (quantitative) growth, and in 2006-2016, it was characterized by intensive (qualitative) growth. In 2017-2020, the yield capacity per hectare decreased almost in all marzes of the RA. As a result, the gross yield of winter wheat annually decreased by 13.54 thousand tons in the mentioned subperiod.

Introduction

Cereal production is one of the key directions of food security in the Republic of Armenia. In the mentioned context it is very important to develop the level of grain production infrastructures, properly implement agro-technological measures and to continuously improve the developing mechanisms of the sector. In the sector of grain/cereal crop production winter wheat has a significant role, since its share in the gross yield of total cereal crop production is rather high. In the RA, throughout 1991-2020, the self-sufficiency rate of wheat didn't increase above 54 %. Only in 2016, the self-sufficiency rate of wheat was 53.2 %, which was mainly due to the yield increase per hectare. The low level of self-sufficiency rate is related to the gross yield of winter wheat, which, in its turn, is directly estimated upon the yield per hectare.

Due to the economic and political situation throughout the years of independence in the Republic of Armenia, almost all economic sectors were developing with constantly changing tendencies.

The aim of this research is to study the main development tendency of winter wheat production indices for the period of 1991-2020, and to disclose the impact of cropland sizes and yield capacity level on the gross yield per the studied subperiods.

Materials and methods

The development tendency of the winter wheat's gross yield has been analyzed via the trend modeling for individual periods and the significant shifts taken place in the entire period have been disclosed. The tendency has been presented by the linear trend:

$$\hat{y}_t = a + b_1 t, \tag{1}$$

where $\hat{y}_t$ is the calculated value of studied indicators by the linear trend, t is the time factor ($t=1; 2;...n$), a, b_1 are the parameters, b_1 describes the absolute growth of the studied phenomena (Eliseeva, 2014). The whole studied period was divided into three analytical subperiods based on the notable variation of time series indicators of gross yield for winter wheat, such as the absolute differences, growth rate, etc. The separate periods included the following years: 1991-2005, 2006-2016, 2017-2020, and the analyses were conducted per marzes of the RA. The separation was done, since the main characteristics of formed trends for each subperiod were significantly different.

For disclosing the effect of the changes in harvest areas and yield amount per hectare on the dynamics of winter wheat's gross yield production, the analyses were done through the index analysis methods. Statistical index analysis method allows to disclose individual effects of qualitative and quantitative factors on the dynamic of studied phenomena (Gromiko, 2005).

The aggregate index and the absolute growth of gross yield are presented as follows:

$$I_{BC} = \frac{BC_1}{BC_0} = \frac{\sum \Pi_1 Y_1}{\sum \Pi_0 Y_0}, \tag{2}$$

$$\Delta_{BC} = BC_1 - BC_0 = \sum \Pi_1 Y_1 - \sum \Pi_0 Y_0.$$

The aggregate index of the yield per hectare and the absolute growth of gross yield due to change of the yield per hectare are presented as follows:

$$I_Y = \frac{\sum \Pi_1 Y_1}{\sum \Pi_1 Y_0}, \tag{3}$$

$$\Delta_Y = \sum \Pi_1 Y_1 - \sum \Pi_1 Y_0.$$

The aggregate index of the sown area and the absolute growth of gross yield due to change of the sown area are presented as follow:

$$I_\Pi = \frac{\sum \Pi_1 Y_1}{\sum \Pi_1 Y_0}, \tag{4}$$

$$\Delta_\Pi = \sum \Pi_1 Y_0 - \sum \Pi_0 Y_0.$$

BC_1 and BC_0 are the gross yields in comparable periods, Π_1 and Π_0 are the sown areas in comparable periods, Y_1 and Y_0 are the yields per hectare in comparable periods (Hakobyan, 2004). The statistical index analysis of winter wheat's gross yield allows to underline the intensive or extensive ways of its growth. The time series of gross yield, sown areas and yield per hectare in the RA are demonstrated in Figures 1, 2, 3.
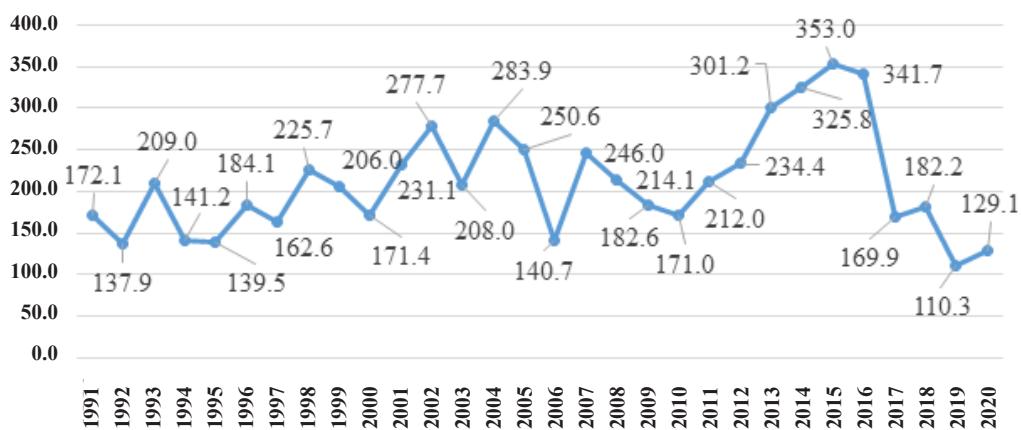
Figure 1. The gross yield of winter wheat in the RA for 1991-2020, 1000 tons *("Agriculture in the Republic of Armenia, 1991-2005" Statistical Compendium - 2001, 2006", "Sown areas of agricultural crops, croplands of perennial plants, gross yield and average yield capacity" Statistical Bulletin, NSS of the RA, 2006-2018, "Sown areas of agricultural crops, croplands of perennial plants, gross yield and average yield capacity" Statistical Bulletin, NSC of the RA, 2019-2021).*
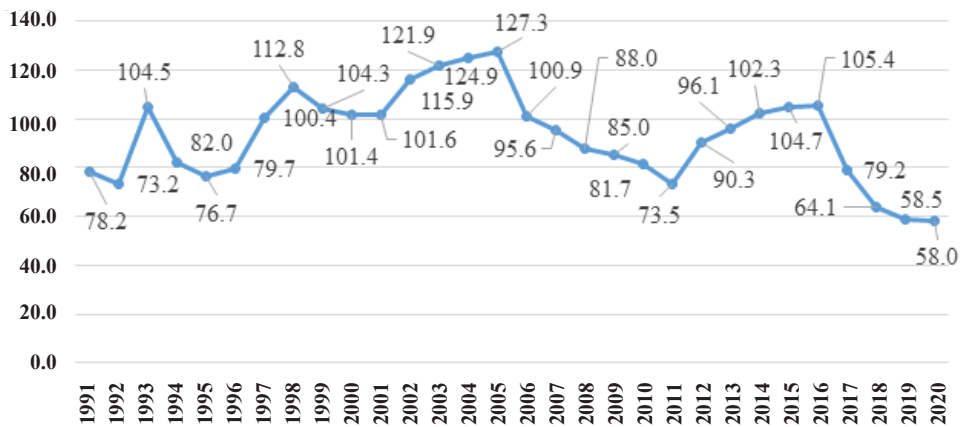
Figure 2. The sown areas of winter wheat in the RA for 1991-2020, 1000 ha *("Agriculture in the Republic of Armenia, 1991-2005"
Statistical Compendium - 2001, 2006 "Sown areas of agricultural crops, croplands of perennial plants, gross yield and
average yield capacity" Statistical Bulletin, NSS of the RA, 2006-2018, "Sown areas of agricultural crops, croplands of
perennial plants, gross yield and average yield capacity" Statistical Bulletin, NSC of the RA, 2019-2021).*
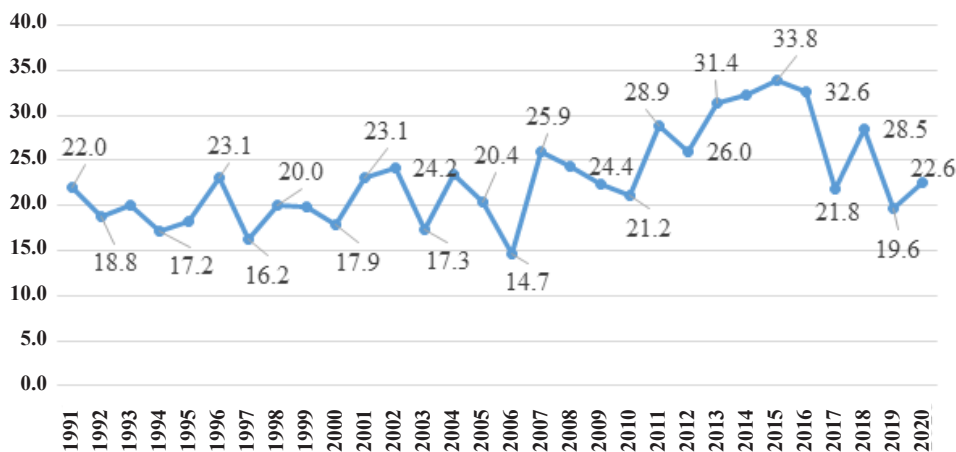
Figure 3. The yield of winter wheat per hectare in the RA, 1991-2020, centner *("Agriculture in the Republic of Armenia, 1991-
2005" Statistical Compendium - 2001, 2006 "Sown areas of agricultural crops, croplands of perennial plants, gross yield
and average yield capacity" Statistical Bulletin, NSS of the RA, 2006-2018, "Sown areas of agricultural crops, croplands
of perennial plants, gross yield and average yield capacity" Statistical Bulletin, NSC of the RA, 2019-2021).*

Results and discussions

The results of trend modeling of gross yield for winter wheat are introduced in Table 1.

Table 1. The trend modeling results of winter wheat for separate periods in the RA*

1991-2005	2006-2016	2017-2020
$\hat{y}_t = 135.5 + 8.07t$	$\hat{y}_t = 134.7 + 18.8t$	$\hat{y}_t = 196.4 - 19.4t$
$R^2 = 0.576, \quad F = 17.6,$	$R^2 = 0.733, \quad F = 24.7,$	$R^2 = 0.551, \quad F = 2.45,$
$t_{b1} = 4.2$	$t_{b1} = 4.9$	$t_{b1} = 1.5$

*Composed by the authors.

Table 2. The average sown areas, gross yield and yield per hectare for winter wheat in the marzes of the RA per separate periods within 1991-2020*

Marzes/Regions	1991-2005			2006-2016			2017-2020		
	Sown area, 1000 ha	Gross yield, 1000 tons	Yield per hectare, centner	Sown area, 1000 ha	Gross yield, 1000 tons	Yield per hectare, centner	Sown area, 1000 ha	Gross yield, 1000 tons	Yield per hectare, centner
Aragatsotn	6.76	10.3	15.2	9.85	26.0	26.4	6.12	12.3	20.1
Ararat	9.20	31.2	33.9	4.89	19.3	39.3	2.32	9.0	38.6
Armavir	14.19	47.9	33.7	5.96	19.9	33.3	3.24	13.0	40.1
Gegharkunik	11.13	16.0	14.3	15.98	44.7	28	11.16	19.9	17.8
Lori	9.63	17.2	17.9	8.25	21.1	25.5	7.96	23.6	29.7
Kotayk	7.57	10.2	13.5	6.35	12.3	19.4	4.41	9.1	20.6
Shirak	20.19	36.3	18.0	21.93	61.1	27.8	16.95	39.2	23.2
Syunik	12.42	17.3	13.9	12.07	30.3	23.2	8.39	16.1	19.1
Vayots Dzor	2.17	2.7	12.2	1.07	2.3	21.7	0.39	0.8	20.0
Tavush	6.22	9.3	15.0	4.33	10.1	23.3	2.8	5.1	18.0
Yerevan	0.29	0.9	31.0	0.14	0.4	32.5	x	x	x
RA	100.32	199.2	19.9	93.05	247.5	26.6	64.94	148.0	22.8

*The indicators are calculated by authors based on NSC data.

Table 3. The results of index analysis of winter wheat gross yield in the marzes of RA for the period of 1991-2005*

Marzes/Regions	The surplus (reduction) of gross yield		Due to changes in			
			sown area		yield per hectare	
	1000 tons	%	1000 tons	%	1000 tons	%
Aragatsotn	0.381	102.2	-0.027	99.8	0.409	102.4
Ararat	2.204	109.2	2.333	109.9	-0.309	99.8
Armavir	2.269	107.3	4.272	110.8	-2.003	96.9
Gegharkunik	0.709	102.7	-0.027	99.9	0.736	102.8
Lori	0.366	102.1	1.004	104.7	-0.638	97.5
Kotayk	0.393	102.7	1.128	106.1	-0.735	96.8
Shirak	-0.667	98.2	1.422	102.9	-2.089	95.4
Syunik	0.272	101.2	0.572	102.4	-0.299	98.9
VayotsDzor	-0.027	99.1	-0.076	97.1	0.049	102.0
Tavush	-0.129	98.8	0.143	101.1	-0.272	97.7
Yerevan	0.026	105.6	0.024	105.4	0.001	100.2
RA	6.261	102.9	7.715	103.5	-1.455	99.5

*Composed by the authors.

According to the main characteristics of trend modeling, the development tendency of winter wheat's gross yield significantly varied between the individual periods. In 1991-2005, the gross yield of winter wheat annually increased by 8.07 thousand tons, in 2006-2016 it annually increased by 18.8 thousand tons. In 2006-2016, the increasing tendency of winter wheat gross yield was much higher than that of observed for the period of 1991-2005; it was mainly due to the growth of yield amount per hectare (index analysis is introduced in Tables 3, 4).

In 2017-2020, the gross yield of winter wheat annually decreased by 19.4 thousand tons due to the decrease of yield per hectare and sown areas (Table 5).

Table 4. The results of index analysis of winter wheat gross yield in the marzes of the RA for the period of 2006-2016*

| Marzes/Regions | The surplus (reduction) of gross yield | | Due to changes of | | | |
| | | | Sown area | | Yield per hectare | |
	1000 tons	%	1000 tons	%	1000 tons	%
Aragatsotn	3.033	113.1	0.609	104.1	2.424	108.7
Ararat	-0.077	99.7	-0.892	96.0	0.816	103.9
Armavir	-1.477	94.0	-1.984	90.8	0.507	103.5
Gegharkunik	2.363	109.9	0.276	101.7	2.087	108.1
Lori	2.549	113.2	0.204	101.8	2.346	111.9
Kotayk	1.329	113.6	-0.059	98.8	1.388	114.9
Shirak	6.949	114.1	0.749	102.6	6.200	111.2
Syunik	3.797	117.7	0.24	102.3	3.557	114.9
Vayots Dzor	0.366	120.3	0.018	102.3	0.348	117.6
Tavush	1.265	117.6	0.139	103.8	1.125	113.3
Yerevan	-0.009	98.1	-0.025	93.5	0.016	104.9
RA	20.053	109.3	1.309	100.9	18.743	108.9

Table 5. The results of index analysis of winter wheat gross yield in the marzes of the RA for the period of 2017-2020*

| Marzes/Regions | The surplus (reduction) of gross yield | | Due to changes of | | | |
| | | | Sown area | | Yield per hectare | |
	1000 tons	%	1000 tons	%	1000 tons	%
Aragatsotn	-2.416	85.3	-3.439	77.1	1.023	110.6
Ararat	-2.066	80.7	-2.142	79.8	0.076	101.1
Armavir	-0.533	96.3	-0.821	94.3	0.287	1.022
Gegharkunik	-0.761	96.2	-1.424	92.7	0.663	1.038
Lori	0.253	101.2	0.305	101.4	-0.052	99.8
Kotayk	-1.097	88.4	-0.836	91.5	-0.261	96.7
Shirak	-3.747	90.4	-4.237	88.9	0.49	101.6
Syunik	-1.479	91.3	-0.997	94.3	-0.482	96.8
VayotsDzor	-0.282	66.5	-0.241	73.5	-0.041	90.5
Tavush	-1.541	71.0	-0.696	89.2	-0.845	79.6
RA	-13.473	91.3	-14.998	90.2	1.524	101.2

*Composed by the authors.

As shown in Table 2, in 1991-2005 the maximum gross yield was recorded in Armavir region, which amounted to 478.53 thousand tons, and in the following period the maximum gross yield of winter wheat was observed in Shirak region, i.e., in 2006-2016 it reached 610.59 thousand tons, while in 2017-2020 it fell down to 392.42 thousand tons.

As the results of analysis indicate, in the period of 1991-2005, in the marzes Ararat, Armavir, Lori, Kotayk and Syunik, the gross yield surplus of winter wheat was only due to the expansion of sown areas, which was associated with the decrease of yield capacity per hectare. The gross yield of winter wheat decreased in the Shirak (by 0.667 thousand tons), Vayots Dzor (by 0.027 thousand tons) and Tavush (by 0.129 thousand tons) regions, which is fully related to the decrease of yield capacity per hectare.

In the mentioned period the sown areas of winter wheat decreased, but the gross yield increased in the Aragatsotn and Ghegharkunik regions. In the Aragatsotn region, the gross yield increased by 0.381 thousand tons due to per hectare yield increase by 0.409 thousand tons, and in the Ghegharkunik region the gross yield increased by 0.709 thousand tons due to per hectare yield increase by 0.736 thousand tons (Table 3).

In 2006-2016 the gross yield of winter wheat decreased in the Ararat, Armavir regions and in Yerevan city mainly due to the decrease of sown areas (Table 4). The gross yield reduction of winter wheat is a positive shift for the agricultural sector in these marzes. During this period, in the abovementioned regions intensive agricultural branches, such as horticulture, viticulture and vegetable growing, were developed. In the other regions the gross yield of winter wheat is characterized by intensive growth. The gross yield surplus of winter wheat in Aragatsotn, Ghegharkunik, Lori, Kotayk, Shirak, Syunik and Vayots Dzor regions was due to the increase of yield capacity per hectare. These mentioned regions are specialized in cereal crops, particularly in wheat production, where wheat production indices have been rather improved. It is no coincidence, that in this period the self-sufficiency rate of wheat reached the maximum level against the other studied years (in 2016 the self-sufficiency rate of wheat was 53.2 %) (Statistical Bulletin, SC of the RA, 2021).

In 2017-2020, almost in all marzes of the RA, the gross yield of winter wheat decreased, again due to the decrease of yield capacity per hectare (Table 5). Due to the reduction of sown area the gross yield of winter wheat decreased in the Aragatsotn, Ararat, Armavir, Ghegharkunik and Shirak marzes. In the marzes of Syunik, Vayots Dzor and Tavush the gross yield decreased due to the reduction of both the sown areas and per hectare yield capacity.

Conclusion

The aim of the research is to disclose the development tendency of winter wheat production, as well as the effect of cropland areas and yield capacity dynamics on the production indices within the entire period of 1991-2020 years. Related to the significant discrepancies in the main indicators of the gross yield dynamics, the studied period was divided into three subperiods: 1991-2005, 2006-2016 and 2017-2020.

In 1991-2005, the difficult socioeconomic situation of the country made the farmers expand the croplands of winter wheat to ensure food security, as a result of which the annual gross yield surplus of winter wheat made 6.26 thousand tons.This period can be considered as the period of qualitative decline of wheat production.

In the next period of 2006-2016, the gross yield of winter wheat significantly increased, especially in such specialized marzes as Shirak, Ghegharkunik, Kotayk, Lori and Syunik. The growth of gross yield was related to the yield increase per hectare by more than 1.5 times. In this period the main indicators of winter wheat production were qualitatively improved.

In 2017-2020, the gross yield of winter wheat annually decreased by 19.42 thousand tons mainly due to the decrease of sown areas and, in individual regions, to the decline of the yield capacity per hectare. These adverse changes resulted in the decrease of wheat self-sufficiency ratio by 54.4 %.

Despite the fact that RA is a grain importing country, the promotion of yield capacity increase should be viewed as one of the key objectives of the agricultural strategic plan. The continuous increase of the yield capacity in the specialized regions of the republic will enable to ensure the development of cereal crop infrastructures and improvement of the relevant mechanisms.

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Study and Development Trend of the Cigarette Market in the Republic of Armenia

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ABSTRACT

The article discusses tobacco cultivation and cigarette production sector as a traditional and developing branch of the RA economy. The entrepreneurial activities of cigarette producing organizations in the RA have been introduced and emphasized.

The production and export indices of cigarette manufacturing companies have been studied, the exported and imported ratios of cigarettes have been collated and increasing - declining trends have been determined. Besides, cigarette market capacity and self-sufficiency rate has been estimated through specific methodology.

Introduction

In Armenia the entrepreneurship in cigarette production has been developed since the post-Soviet years. Per the data of 2020, five companies are already engaged in the mentioned sector: "Grand Tobacco" LLC, "International Masis Tabak" LLC, "Masis Tobacco" LLC, "SPS Cigaronne" LLC and "Armenian Tobacco Company" LLC. Identification of the issues related to the entrepreneurial activities of cigarette and cigar manufacturing companies of the RA is rather relevant for the economy of Armenia. According to the official data, in the last five years, cigarette is the second most exported product from Armenia. The specific weight of tobacco products manufacture in the overall industrial products of the RA amounted from 2 % (2010) up to 9.4 % (2020). The need for the development of this branch is enhanced upon the availability of land and labor resources. By providing the branch companies with domestic raw materials and reducing the dependence on the imported raw materials, hence, avoiding the fluctuations in international exchange rates, not only the economic, but also one of the most important social issues in the RA, i.e., reduction of unemployability rate, will be handled. That is, an opportunity can be created to provide, for instance, the residents of border regions with appropriate jobs.

Materials and methods

Cigarette and cigar production is a traditional and fast growng subbranch of Armenian economy provided with both domestic and imported raw material (Parsyan, 2021). All companies engaged in entrepreneurial activities in the cigarette and cigar production sector are involved in the list of 1000 large tax payers annually published by the State Revenue Committee of the RA. According to the data provided by the SRC, in 2016, 2017 and 2018 "Grand Tobacco" LLC was in the second position among the tax payers, being the second only to "Gazprom Armenia" in 2016-2017 and to "Zangezur Copper-Molybdenum Combine" in 2018. In 2019-2020, "Grand Tobacco" LLC again topped the list of the RA tax payers (petekamutner. am, 22.10.21). The overwhelming share of cigarette manufacturing companies in the total specific weight of the tax revenues and duties accreted in the RA state budget is related to the growing volumes of the mentioned production and to the amount of income taxes paid from the salaries of great number of employees, as well as to the current high rates of added value and excise taxes (Parsyan, 2017#3). In 2016-2020, the share of tax receipts entered the RA state budget from the companies engaged in the entrepreneurial activities of cigarette production in the RA tobacco market grew up from 3.1 % to 6.5 %.

Thus, the sizes of tax and duties paid to the state budget by the cigarette and cigar manufacturing companies are sustainably growing, which directly promotes the provision of efficiency increase in fiscal policy.

The development tendencies of cigarette and cigar products manufacture, their import and export ratios have been investigated and the market capacity, as well as self-sufficiency rate has been estimated through the method introduced in "Food Security and Poverty" bulletin (Statistical Bulletin, Yerevan-2019).

$$Market\ capacity = Production + Import - Export.$$

$$Self\text{-}sufficiency\ rate = \frac{Production}{Production + Import - Export} \times 100\ \%.$$

Results and discussions

Cigarette production sector has been one of the dynamically developing branches of the industry in the Republic of Armenia for the last 20 years. Moreover, up to 2020, before the prevalence of the coronavirus pandemic Covid–19, the cigarette exporting volumes had been annually growing, so becoming one of the sustainable sources for foreign currency flow into Armenia.

In 2020, the cigarette production rate in Armenia, in physical terms, decreased by 17.8 % against the previous year. As of January-August, 2021, the cigarette production volumes were reduced by 16.8 % as compared to the same period of 2020. The data investigation indicates that cigarette production sizes demonstrate decreasing tendency. It is noteworthy, that a considerable decline in the cigarette production volumes was observed still from March, 2020, when the pandemic started spreading in Armenia very rapidly and causing huge damages to almost all economic branches. As a result, according to the data retrieved in 2020, the physical volumes of cigarette production were reduced by 16.8 % falling down to the level recorded in 2017.

It is also worth mentioning, that the specific weight of cigarette manufacture in the overall structure of the RA processing industry has recorded an increasing tendency in the recent years. For example, if in 2011 it made 2.5 %, then in 2019 it amounted to 13.4 %, while in 2020 - 11 %. The indices for 2011-2021 published by the National Statistic Committee are introduced in Figure 1.
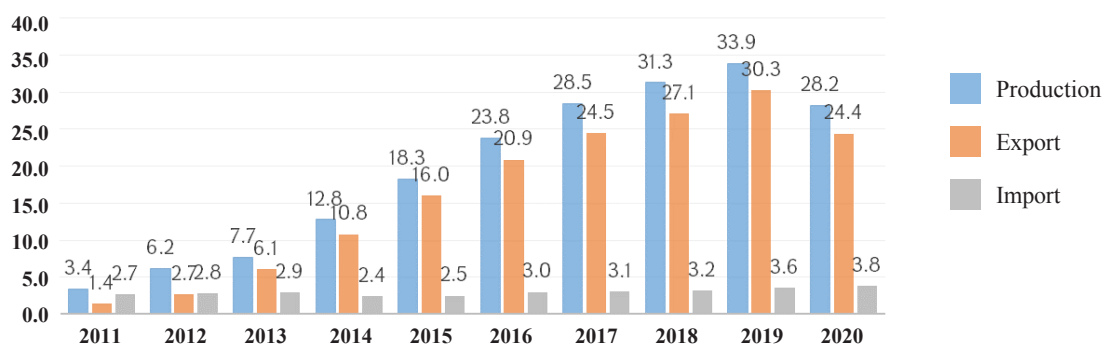
Figure 1. Cigarette production, export and import sizes in the RA within the period of 2011-2020, bln n (Statistical Bulletin, armstat. am 22.10.21) *(composed by the authors)*.

bln n
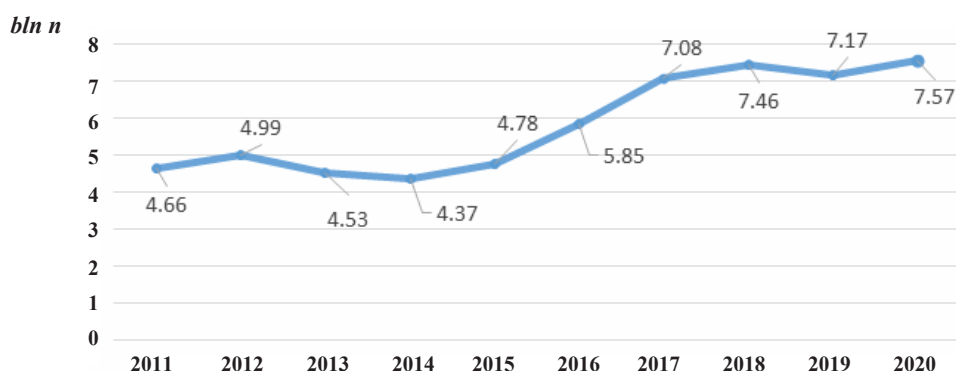
Figure 2. The cigar and cigarette market capacity in 2010-2020 in RA *(composed by the authors)*.
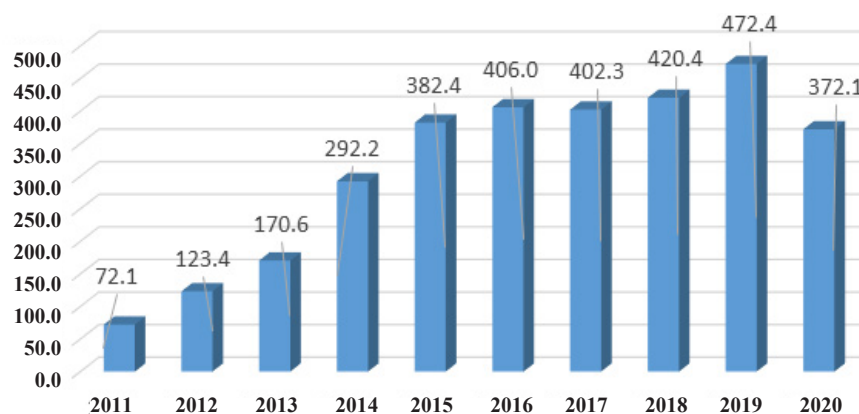
Figure 3. Self-sufficiency rate of cigarette market in 2011-2020, % *(composed by the authors)*.

In 2011-2020, parallel to the increase of cigarette production sizes, its export volumes grew up. About 83-88 % of the produced cigarettes is annually exported from Armenia. In 2020, 24.4 bln n cigarettes were exported from Armenia, the total customs cost of which made 241.1 mln US dollars. Compared to 2019, the export volumes decreased by 3.8 bln n or by 13.5 %, while the cost - by 32 mln US dollars or by 11.7 %.

Despite the reduction of the mentioned indices, cigarette is still in the list of the products with highest exported customs value from Armenia. Particularly, in 2019, it constituted 10 % of exported products in Armenia and in 2020 it made 9.5 %. Already in the first half of 2021, cigarettes with the estimated cost of about 101.0 mln US dollars were exported from Armenia, which, compared to the same period of the previous year, is reduced by about 10 mln US dollars or by 8.7 %. Armenian cigarettes are mostly exported to Iraq, Syria, UAE, as well as to Georgia, Russia, Ukraine and other countries. Iraq accounts for

about 61 % of the exported cigarettes in 2020, Syria – for 16 %, UAE – for 12 %, etc.

The significance of the specific industrial branch in the national economic system of the country is also based on the identification of the countries, where the sale of the branch product is implemented, or those with which partneship relations are created in order to supply the branch with raw materials and other facilities. For example, the economic entities, engaged in the entrepreneurial activities in the territory of Armenia, purchase raw materials and accessories for cigarette production from such partner countries as Iran, Greece, Bulgaria, Brazil, Republic of South Africa (RSA), Austria, France, Italy, Indonesia, Russian Federation and Turkey.

It is remarkable that the raw products and other supplies required for cigar and cigarette manufacture is mainly purchased by the local companies from abroad. Some accessories for cigarette production are produced just by local companies not to be dependent on foreign market.

If the production of Virginia, Burley and Samsun tobacco varieties grown in different regions of the RA is able to meet about 15 % of the raw product demand in cigarette manufacturing companies, then the mentioned economic entities face serios problems in acquiring other types of raw products.

The import sizes of cigarettes demonstrate sustainable growth for the period of 2011-2020: in 2020, the imported volume increased in 1.4 times, and the export volume - in 17.4 times against the same indices recorded for 2011. In 2011-2020, the cigarette market capacity in Armenia increased by 62.4 % (Figure 2). Though in 2020, the cigarette manufacture volume was reduced from 30.3 bln n to 28.17 bln n, one of the reasons of the growth in the cigarette market capacity in the RA was the increase in cigarette import volumes.

The self-sufficiency rate of cigarette market annually increased within the period of 2011-2020 due to the increase of cigarette production volumes in the country and their sustainable import sizes. The highest self-sufficiency rate was recorded in 2019, nevertheless, the index of 2020 already demonstrated a decreasing tendency. At the same time, it is worth mentioning, that the overwhelming part of cigarettes produced in the RA for recent years is being exported.

Conclusion

Tobacco cultivation in the RA has a rather long history. Armenian cigarettes are in great demand both in internal market and in dozens of foreign countries of the world. They are distinguished by high qualitative properties (color, strength). The cigar and cigarette manufacturing organizations of the RA have a number of achievements in their entrepreneurial activities. For dozens of years the cigar and cigarette production sector had been one of the dynamically developing branches in the processing industry of Armenia, anyhow, in 2020 the mentioned sector recorded a decline in the production and economic indices. This tendency was related to the unstable economic situation, rising prices, reduction of population's purchase power, pandemic and war conditions.

Though cigarette is not considered a staple product, its specific weight /share should not be ignored in the overall structure of household expenditures. During 2004-2019, according to the data of statistical-analytical report "Social Snapshot and Poverty in Armenia", the monthly average share of cigarette in the structure of nominal household consumption expenditure made 808-1653 AMD per capita of household (statistical-analytical report, Yerevan, 2018). That is the increase in cigarette prices in the RA has a direct causal effect on the budget expenditure items of entire population and individual households.

Despite the circumstance that the production capacity of tobacco varieties (Virginia, Burley and Samsun) as a cigarette raw material is rather high in Armenia, in 2016-2020 the cigarette and cigar manufacturing companies purchased the cigarette raw products from abroad. Here the companies have to deal with high production, financial and commercial risks.

So, investigating the indices of cigarette production, its export and import volumes, as well as the market capacity and self-sufficiency rate within the period of 2011-2020, it has been found out that the mentioned indices demonstrated a sustainably growing trend. Some variations towards the decreasing trend were related to the pandemic and war conditions. It can be stated that in 2011-2020, the cigarette manufacturing companies were actively engaged in entrepreneurial activities both in Armenia and abroad. Tobacco growing and cigarette manufacturing sector is a sustainably developing branch for Armenia and it is not only of economic but also of social significance providing thousands of work positions.

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Synthesis of Potentially Bioactive Hydrazones of Pyrimidine and 1,3,5-Triazine

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ABSTRACT

The reaction of the pyrimidine and 1,3,5-triazine hydrazides with various aldehydes formed corresponding hydrazones. Synthesized compounds are endowed with potential bioactivity. In laboratory-vegetation screening, the obtained compounds showed a pronounced stimulating effect on plant growth. The activity of the tested compounds varied in the range of 46–88 % as compared to heteroauxin. Compounds that showed an activity above 70 % in the experiment will be selected for deeper study and further field tests.

Introduction

Most pharmaceutical preparations that mimic biologically active natural substances consist of heterocyclic scaffolds. Hydrazides and their derivatives, in particular hydrazones, are often used as starting compounds to obtain new heterocyclic structures. Hydrazine derivatives occupy a special place in the chemotherapy of tuberculosis (Mashkovskiy, 2019). Isonicotinic acid hydrazide (isoniazid) has been used in medical practice for more than half century and has not lost its significance to this date. Based on this, ftivazide, saluside, metazide and other modified analogs with improved pharmacological properties have been obtained. In medical practice, antidepressants iproniazid and nialamide (monoamine oxidase inhibitors) are widely used (Mashkovskiy, 2019).

Studies of new hydrazine derivatives are ongoing, in which compounds with antimicrobial (Masunari and Tavaris, 2007, Loncle, et al., 2004, Küçükgüzel, et al., 2003, Vicini, et al., 2002), anti-inflammatory (Todeschini, et al., 1998), anti-tuberculosis (Bijev, 2006), antitumor (Gürsoy and Ulusoy-Güzeldemirci, 2007), antimalarial (Gemma, et al., 2006), antidepressant (Ergenç, et al., 1998) and anticonvulsant (Ragavendran, et al., 2007) activities have been revealed. Some hydrazide derivatives, particularly, herbicides (benquinox, saijunmao, phenoxyaryl hydrazides of nicotinic acid) (http://www.alanwood.net/pesticides/) and also the compounds with plant growth stimulating activity (Gomktsyan, et al., 2012, Yengoyan, et al, 2017, Pivazyan, et al., 2019, Shainova, 2019) are used in agriculture.

Materials and methods

We have developed an efficient method for obtaining hydrazine (α-methylhydrazino)-sym-triazines (Dovlatyan, et al., 1989).

Studies have shown that these compounds have herbicidal properties (Dovlatyan, et al., 1981, Dovlatyan, et al., 1980,1986) and some of their salts have fungicidal effect (Dovlatyan, 1986).

In order to expand the range of biologically active compounds, a number of compounds were interacted with aldehydes in water and appropriate hydrazones were obtained in room temperature.

Results and discussions

The targeted hydrazones, N-methylhydrazones of pyrimidine and 1,3,5-triazine were synthesized upon the reaction of the corresponding hydrazides and various aryl aldehydes in hydrochloric acid solution (Diagam). The obtained hydrazones can exist as two possible E and Z structural isomers. However, according to the data of ^{1}H and ^{13}C NMR spectra, the sterically more beneficial E-isomer is predominant, and only signals of this isomer are observed in the NMR spectra. The obtained compounds were subjected to laboratory vegetation tests to determine herbicidal, fungicidal, growth-regulating properties. Almost all of the compounds obtained showed a stimulating effect on plant growth. The experiments were carried out on seeds and seedlings of common beans (Phaseolus vulgaris L.). The effect of aqueous suspensions of compounds at the concentrations of 25 and 50 mg/L on seed viability, germination, and seedling growth was studied. These data were compared with the effect of heteroauxin solutions of the same concentrations. The activity of the tested compounds varied in the range of 46–88 % as compared to heteroauxin. In some cases, the growth-stimulating effect of solutions with a lower concentration turned out to be stronger than that of more concentrated solutions. Compounds that showed an activity above 70 % in the experiment will be selected for deeper study and further field tests using their solutions with concentrations less than 25 mg/L.
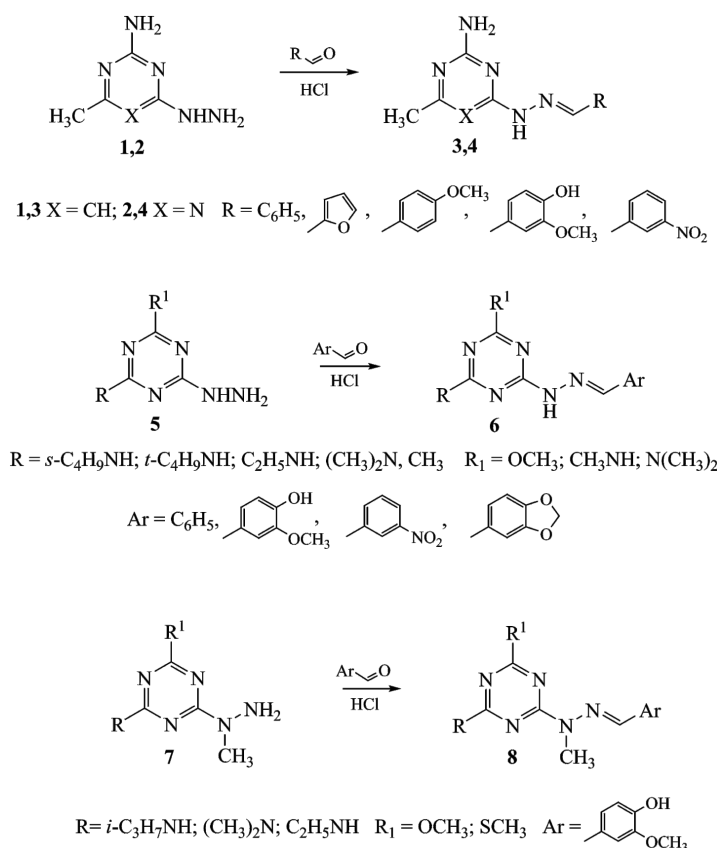
Diagram. Synthesis of hydrazones, N-methylhydrazones of pyrimidine and 1,3,5-triazine *(composed by the authors)*.

Experimental

^{1}H and ^{13}C NMR spectra were recorded at 30°C on a Varian Mercury-300 NMR spectrometer (300 and 75 MHz, respectively) in a mixture of solvents CCl4–DMSO-*d6* (3:1); TMS was used as an internal standard. The reaction progress and the purity of the obtained compounds were monitored by TLC on Silufol UV-254 plates; benzene–hexane, 2:1, mixture was used as an eluent. Elemental analysis was performed on a Eurovector EA3000 CHNS analyzer. Melting points were determined by the capillary method and were not corrected.

General procedure

To the mixture of compounds 1,2,5 or 7 (10 mmol), 10 mL of water and 1,5 mL of HCl (36 %), 10 mmol of various aldehydes were added and the reaction mixture was stirred at 20 °C for 24 h. After adding water (10-15 mL) the precipitate was filtered off and dried.

Compounds examples

(E)-4-(2-benzylidenehydrazinyl)-2-amino-6-methylpyrimidine:

Compound yield - 82 %, m.p. 255°C (decomp). ^{1}H NMR, δ: 2.40 (s, 3H, CH$_3$); 6.61 (s, 1H, CH-pyrim.); 7.34-7.72 (m, 5H, C$_6$H$_5$); 7.80 (br.s, 2H, NH$_2$); 8.31 (s, 1H, CH=N); 13.54 (br.s, 1H, NH). ^{13}C NMR, δ: 18.4, 95.5, 126.9, 128.1, 129.6, 133.6, 147.1, 153.6, 155.5, 162.7. Anal.calc.: Found: C, 63.29; H, 5.67; N, 30.93. C$_{12}$H$_{13}$N$_5$. Calcul.: C, 63.42; H, 5.77; N, 30.82.

(E)-4-(2-(4-methoxybenzylidene)hydrazinyl)-2-amino-6-methylpyrimidine:

Compound yield - 88 %, m.p. 170-172°C. ^{1}H NMR, δ: 2.26 (s, 3H, CH$_3$); 3.82 (s, 3H, OCH$_3$); 6.36 (br.s, 2H, NH$_2$); 6.41 (s, 1H, CH-pyrim.); 6.85-7.61 (m, 4H, C$_6$H$_4$); 8.02 (s, 1H, CH=N); 11.04 (br.s, 1H, NH). ^{13}C NMR, δ: 21.6, 54.6, 92.3, 113.5, 127.1, 127.7, 142.8, 159.8, 160.1, 161.0, 162.3. Anal.calc.: Found: C, 60.74; H, 5.95; N, 27.40. C$_{13}$H$_{15}$N$_5$O. Calcul.: C, 60.69; H, 5.88; N, 27.22.

(E)-4-(2-(furan-2-ylmethylene)hydrazinyl)-2-amino-6-methylpyrimidin:

Compound yield - 83%, m.p. 260 °C (decomp). ^{1}H NMR, δ: 2.39 (s, 3H, CH$_3$); 6.52-6.54 (d×d, J$_1$=3.4 Hz, J$_2$=1.8 Hz, 2H, CH=CH fur.); 6.81 (d, J$_1$=3.4 Hz, 1H, CH-fur.); 7.64 (s, 1H, CH-pyrim.); 7.76 (br.s, 2H, NH$_2$); 8.19 (s, 1H, CH=N); 12.20 (br.s, 1H, NH). ^{13}C NMR, δ: 18.4, 93.0, 111.6, 113.0, 136.8, 144.3, 149.0, 153.6, 155.4, 162.5. Anal.calc.: Found: C, 55.37; H, 5.02; N, 32.43. C$_{10}$H$_{11}$N$_5$O. Calcul.: C, 55.29; H, 5.10; N, 32.24;

(E)-4-(2-benzylidenehydrazinyl)-2-amino-6-methyl-1,3,5-triazine:

Compound yield - 81 %, m.p. 280-282 °C. ^{1}H NMR, δ: 2.28 (s, 3H, CH$_3$); 6.80 (br.s, 2H, NH$_2$); 7.25-7.73 (m, 5H, C$_6$H$_5$); 8.10 (s, 1H, CH=N); 11.08 (br.s, 1H, NH). ^{13}C NMR, δ: 24.0, 126.4, 127.9, 128.4, 134.7, 143.4, 173.5. Anal.calc.: Found: C, 57.96; H, 5.25; N, 36.96. C$_{11}$H$_{12}$N$_6$. Calcul.: C, 57.88; H, 5.30; N, 36.82.

(E)-4-(2-(4-methoxybenzylidene)hydrazinyl)-2-amino-6-methyl-1,3,5-triazine:

Compound yield - 83%, m.p. 248-250 °C. ^{1}H NMR, δ: 2.20 (s, 3H, CH$_3$); 3.81 (s, 3H, OCH$_3$); 6.50 and 7.17 (br.s, 2H, NH$_2$); 6.84-7.63 (m, 4H, C$_6$H$_4$); 8.00 (s, 1H, CH=N); 10.74 (br.s, 1H, NH). ^{13}C NMR, δ: 24.4, 54.7, 113.7, 127.4, 127.7, 128.1, 142.7, 159.8, 163.7; 166.5. Anal.calc.: Found: C, 55.72; H, 5.38; N, 32.38. C$_{12}$H$_{14}$N$_6$O. Calcul.: C, 55.80; H, 5.46; N, 32.54.

(E)-4-((2-(4-(ethylamino)-6-methoxy-1,3,5-triazin-2-yl)-2-methylhydrazono)methyl)-2-methoxyphenol:

Compound yield - 67%, m.p. 203-205 °C. ^{1}H NMR, δ: 1.29 (t, J=7.2, 3H, NCH$_2$CH$_3$); 3.50 (q, J=7.2, 2H, NCH$_2$CH$_3$); 3.64 (s, 3H, NCH$_3$); 3.98 (s, 3H, OCH$_3$); 4.00 (s, 3H, OCH$_3$); 6.75-7.97 (m, 3H, C$_6$H$_3$); 8.14 (s, 1H, CH=N); 10.62 (br.s, 1H, OH). ^{13}C NMR, δ: 13.7, 30.2, 35.5, 55.2, 56.5, 110.7, 114.5, 124.1, 124.8, 148.0, 148.1, 155.1, 157.2, 168.4. Anal.calc.: Found: C, 54.14; H, 6.01; N, 25.41. C$_{15}$H$_{20}$N$_6$O$_3$. Calcul.: C, 54.21; H, 6.07; N, 25.29.

Conclusion

Based on the aforestated methods and examples, it can be summed up that a series of pyrimidine and 1,3,5-triazine hydrazides derivatives were synthesized, which, upon biological screening, showed a pronounced stimulating effect on plant growth. The most active ones have been selected for deeper research and subsequent field trials.

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Hymenopteran Parasitoids of Leaf Miners *(Diptera: Agomyzidae)*

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ABSTRACT

The current article discusses the taxonomic composition of parasitoids and the infestation degree of leaf miners with parasitoids.

The species composition of hymenopteran parasitoids of the Braconidae, Eulophidae and Pteromalidae families is studied and presented for the first time in the Artsakh Republic. Eight parasitoid wasps were reared from the 10 leaf-mining flies which attacked 19 plant species.

Introduction

Many species of leaf miners (Diptera, Agromyzidae) are serious pests for the cultivated, medicinal and ornamental plant species necessary for humans, and even such species as vegetable leaf miner (L. sativae), tomato leaf miner (L. bryoniae), South American or serpentine leaf miner (L. huidabrensis) and others are considered quarantine species (Spencer, 1989, 1990, Lonsdale, 2011, CABI, 2013, Grigoryan, et al., 2020). As a result of climate changes observed in recent years, as well as the import of new types of cultivated and ornamental plants in open and covered soils, the habitats of leaf miners and the intensity of infection are noticeably increasing. Based on the degree of damage caused by mining flies, various pesticides are often used against plant pests in many countries, which generally do not have a selective effect.

Repeated application of pesticides also destroys useful entomofauna, including the natural enemies of leaf miners, which play an important role in influencing the number of pests. In addition, leaf miners gain a high tolerance through the multiple use of chemicals (Keil, et al., 1985).

The most effective method of controlling leaf miners is the use of natural enemies, such as pathogenic bacteria, parasitoids and insect predators, which are also harmless to the environment (Shojaey, et al., 2020). Based on the undesirable consequences of chemical control in recent years, in many countries, including Artsakh, much attention has been paid to the research of the natural enemies of leaf miners. Therefore, our main purpose was to study the parasitoids᾽ species diversity of mining flies in Artsakh. The species diversity of the family Eulophidae (Hymenoptera) and the peculiarities of their parasitism

were studied by Askew and Shaw in England (Askew and Shaw, 1974). Recently, the species composition of subfamilies Eulophinae, Entedoninae and Tetrastichinae has been studied in Iran (47 species) (Yefremova, et al., 2007), 17 species of ecto- and endoparasitoids of chalcidoid parasites (Hymenoptera, Eulophidae) have been explored in the Middle Volga River Basin (Strakhova, et al., 2013), while 15 species of hymenopterous parasitoids were found in northwestern Iran (Iranian Azerbaijan) in 2015, 3 of which belong to the Braconidae family, 10 - to the Eulophidae family, 2 - to the Pteromalidae (Lotfalizadeh, et al., 2015). As a result of research in 2020, the entomofauna of Iran was added with new parasitic species of the family Pteromalidae (Shojaey, et al., 2020).

It has been confirmed that parasitoids play an essential role in the regulation of leaf miners' number in nature. Hymenoptera is considered one of the largest orders of insects with huge species diversity. More than two dozen families of the order, such as Ichneumonidae, Braconidae, Sphecidae, Pteromalidae and others, parasitize insects and pests reducing their numbers in nature. Larvae of hymenopteran parasitoids having developed through the early instar larvae of host insects gradually destroy them. This is one of the important features that distinguish parasitoids from parasites (Askew, 1971), which do not kill their hosts. Parasitoid larvae can live inside host organism (endoparasitoid) or outside the host organism (ectoparasitoid).

Noyes J. (2004) recorded 300 species of parasitoids, more than 80 of which parasitize leaf miners of the genus Liriomyza *(Diptera: Agromyzidae)*. The complexity of the study of leaf miners' parasitofauna occurs during pupation when their larvae come out of the mines, taking with them the chalcid parasitoids (Askew and Shaw, 1974).

Our task was to detect the leaf miner pupae infested with parasitoids and rear adult parasitic species, to conduct structural research for precise differentiation, to study the biological and ecological features of the parasitoids' development as well as the character and rate of infestation.

Materials and methods

The research material was leaves infected with leaf miners and collected from different regions of Artsakh Republic for the periods of April 2018 to August 2020. The infected leaves were stored in glass tubes, filled with wet sand (23-25°C) until pupae formation. Usually the development of the larva lasts 4-5 days (23-25ºC), pupal development takes 7-14 days (25-28ºC). Prolonged pupal development is associated with the formation of mold or

with the development of natural enemies inside leaf miner pupa, which usually lasts 10 - 20 days. We separated the infested pupae, moved them to another vial (25-28ºC, 70 ± 5 % RH) and constantly followed the development process. After 24 hours the emerged adult parasitoids were stored in 75 % ethyl-alcohol for future work. Species were classified according to the accepted taxonomic classification (Boucek, 1988), and various identification guides were used to differentiate morphological features (Hansson, 1985, Graham, 1959, LaSalle and Parella, 1991, Achterberg, 1993, Shaw, 1991). Morphological studies of parasitoids were carried out in the Biological Research Laboratory of Artsakh State University using XSZ-0800 and ADSM302 digital microscopes.

Results and discussions

As a result of our research, in Artsakh Republic we found 8 parasitoid species belonging to 8 genera, 6 subfamilies and 3 families: Braconidae (2 species), Eulophidae (4 species) and Pteromalidae (2 species) (Table 1). If the development of uninfected pupae at a temperature of 25-28°C takes 7-14 days, then the development of infested pupae takes longer, about 10-20 days.

Most species of Braconidae family (Hymenoptera: Ichneumonoidea) are endo- and ectoparasitoids of eggs and larvae. A number of parasitoids of this family are isolated from the host organism at the end of the development cycle to complete development beyond it (Shaw and Huddleston, 1991). Family Braconidae is represented by two subfamilies: *Opiinae,* Blanchard, 1845 and *Alysiinae*, Leah, 1815, which are endoparasitoids. The development of leaf miners' larvae infested with parasitoids is not interrupted, their larvae continue to feed and mature, and even pupate. The development of parasitoids ends inside host larvae and pupae, and the adult braconid emerges from the pupa (Li, et al., 2013).

Species of the family Eulophidae (Hymenoptera: Chalcidoidea) are widely distributed and are considered ectoparasitoids of larvae and pupae. The family includes 290 genera and 4300 species (Noyes, 2001).

Family Pteromalidae (Hymenoptera: Chalcidoidea) is one of the largest families of the Chalcidoidea superfamily, numbering 3 500 species and 600 genera (Noyes, 2002, 2003). Parasitic pteromalids lay eggs inside hosts' eggs, larvae and pupae. It should be noted that at the embryonic stage, the infested leaf miners' development is not interrupted and continues until the formation of larva, then pupa, where the development of leaf miners is ceased and the adult parasitic wasp emerges from pupa.

Table 1 shows the species composition of mining flies, which attack various plant species, and their parasitoids.

The following table (Table 2) shows the number of parasitoids developing in different species of mining flies on one plant.

Table 1. Taxonomic composition of the studied parasitic wasps*

Super-family	Family	Subfamily	Genus	Species	Host species of mining flies	Infected plant species
Ichneumonoidea Haliday, 1838	Braconidae Nees, 1812	Opiinae Blanchard, 1845	Opius Wesmael, 1835	Opius sp.	Phytomyza horticola (Goureau, 1851)	Cardaria draba (L.) Desv. (Brassicaceae)
					Liriomyza bryoniae (Kaltenbach, 1858)	Capsicum annuum L. (Solanaceae)
					Liriomyza sativae (Blanchard, 1938)	Phaseolus vulgaris L. (Fabaceae)
						Cucurbita pepo L. (Cucurbitaceae)
					Calycomyza humeralis (von Roser, 1840)	Erigeron canadensis L. (=Conyza canadensis (L.)
					Phytomyza lappae (Goureau, 1851)	Arctium lappa L. (Asteraceae)
					Amauromyza leonuri (Spencer, 1971)	Ballota nigra L. (Lamiaceae)
						Lamium album L. (Lamiaceae)
		Alysiinae Leah, 1815	Chaenusa seminervata van Achterberg, 2012	Chaenusa seminervata sp.	Liriomyza congesta (Becker, 1903)	Trifolium repens L. (Fabaceae)
					Liriomyza endiviae (Hering, 1955)	Lactuca sativa L. (Asteraceae)
					Phytomyza horticola (Goureau, 1851)	Raphanus sativus L. (Brassicaceae)
					Phytomyza plantaginis (Robineau-Desvoidy, 1851)	Plantago major L. (Plantaginaceae)
Chalcidoidea	Eulophidae Westwood, 1829	Eulophinae Westwood, 1829	Diglyphus Walker, 1844	Diglyphus isaea (Walker, 1838)	Liriomyza endiviae (Hering, 1955)	Lactuca sativa L. (Asteraceae)
		Entedoninae Forster, 1856	Pediobius Walker, 1846	Pediobius metallicus (Nees, 1834)	Phytomyza horticola (Goureau, 1851)	Dahlia pinnata Cav. (Asteraceae)
						Sisymbrium loeselii L. (Brassicaceae)
						Galinsoga parviflora Cav. (Asteraceae)
			Neochrysocharis Kurdjumov, 1912	Neochrysocharis sp.	Phytomyza horticola (Goureau, 1851)	Leucanthemum maximum Ramond (DC.) (Asteraceae)
			Apleurotropis Girault, 1913	Apleurotropis sp.	Phytomyza horticola (Goureau, 1851)	Alliaria petiolata (Bieb.) Cavara et Grande (Brassicaceae)
	Pteromalidae Dalman, 1820	Pteromalinae Dalman,1820	Nasonia vitripennis (Walker, 1836)	Nasonia sp.	Amauromyza flavifrons (Meigen, 1830)	Saponaria officinalis L. (Asteraceae)
		Miscogastrinae Walker, 1833	Halticoptera Spinola, 1811	Halticoptera sp.	Liriomyza bryoniae (Kaltenbach, 1858)	Beta vulgaris L. (Amaranthaceae)

*Composed by the authors.

Table 2. Parasitoids of leaf-mining flies of the family Agromyzidae**

Hymenopteran Parasitoids	Leaf-mining flies (n*)										
	Amauromyza leonuri (9)	Amauromyza flavifrons (5)	Calycomyza humeralis (6)	Liriomyza congesta (6)	Liriomyza endiviae (4)	Liriomyza sativae (29)	Liriomyza bryoniae (8)	Phytomyza horticola (29)	Phytomyza plantaginis (14)	Phytomyza lappae (4)	Total
Opius sp.	9		2			9	2	4		3	29
Chaenusa seminervata sp.				5	2			2	6		15
Diglyphus isaea					2						2
Pediobius metallicus								6			6
Neochrysocharis sp.								3			3
Apleurotropis sp.								2			2
Nasonia sp.		4									4
Halticoptera sp.							2				2
Total	9	4	2	5	4	9	4	17	6	3	63
Degree of infestation (%)	100	80	33.3	83.3	100	31	50	59	43	75	

* - *quantity of leaf miners.*

**Composed by the authors.

The most common parasitoids of the Braconidae family are the species *Opius sp.* (46 %) and *Chaenusa seminervata sp.* (24 %) (Figure 1), which together makes up 70 % of parasitoids. A large number of parasitoids were reared from *Ph. horticola* (27 %). A relatively large amount of *Opius sp.* was reared from the species of *Am. leonuri* and *L. sativae*, whose infestation is 100 % and 31 %, respectively.

Genus *Opius* Wesmael, 1835 *Opius sp.*

Genus *Chaenusa seminervata* van Achterberg, 2012
Chaenusa seminervata sp.

Figure 2. Family Braconidae Nees, 1812.
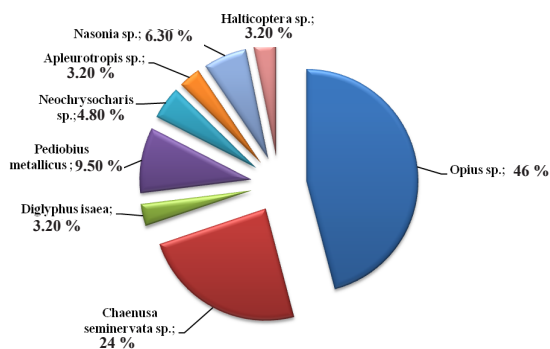
Figure 1. Quantitative ratio of parasitoids *(composed by the authors)*.

Genus *Pediobius* Walker, 1846   *Pediobius metallicus* (Nees, 1834)

Genus *Apleurotropis* Girault, 1913   *Apleurotropis sp.*
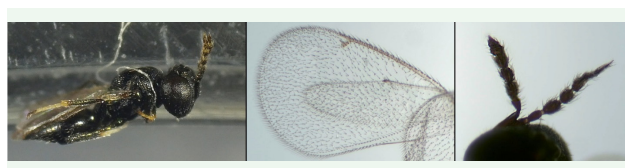
Genus *Diglyphus* Walker, 1844   *Diglyphus isaea* (Walker, 1838)
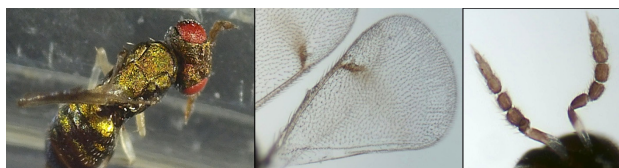
Genus *Neochrysocharis* Kurdjumov, 1912   *Neochrysocharis sp.*

Figure 3. Family Eulophidae Westwood, 1829.

Genus *Nasonia vitripennis*, Walker, 1836 *Nasonia sp.*

Genus *Halticoptera* Spinola, 1811 *Halticoptera sp.*

Figure 4. Family Pteromalidae Dalman, 1820.

The infestation rate of *L. congesta* parasitized by *Chaenusa seminervata sp.* is 83.3 %, and the infestation rate of *Ph. plantaginis* is 43 %.

It can be noted that specialized parasitoids are more effective in regulating the number of leaf miners than non-specialized species with a density of less than 10 %.

We have also presented the reared parasitic species of the Braconidae (Figure 2), Eulophidae (Figure 3) and Pteromalidae families (Figure 4).

Conclusion

During the research, we found 8 species of parasitoids belonging to the Braconidae, Eulophidae and Pteromalidae families, which parasitize the species of the families Amauromyza, Calycomyza, Liriomyza and Phytomyza. Species of Braconidae family (Opius sp. - 46 %, Chaenusa seminervata sp. - 24 %) have a high occurrence rate, but the Eulophidae family stands out with its species diversity. 5 parasitic species were reared from the polyphagous Ph. horticola species, which is considered as a pest of cucurbits and ornamental plants. Considering the high rate of parasitism, we can assume that parasitic species play an important role in regulating the number of mining flies. As above-mentioned, when we use pesticides against leaf-mining flies, it is necessary to take into account that in order to preserve important fauna, we should also know the infestation period and development features of parasitic wasps.

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Study of the Species Composition of Harmful Organisms in Akunk Educational Research Farm

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ABSTRACT

The article considers the species composition of pests studied in the apple and pear orchards of Akunk Organic Agricultural Experimental Farm in 2020-2021.

Twenty four species of harmful organisms have been identified, 17 of which are pests, 1 is a tick and 6 are diseases. Among the harmful organisms the *Hoplocampa testudinea* and *Cydia pomonella* were identified on the apple trees, and *Fire blight* was found on the pear trees.

Introduction

Organic farming is a system aimed at improving and promoting agricultural production, which considers the soil improvement as a cornerstone in the production of high quality and ecologically clean food. Organic agriculture is a system where toxic substances and chemical fertilizers are not used, while organic fertilizers are used instead.

The amount of nutrients in organic food is up to 3 times more than in the crops grown with the use of pesticides and mineral fertilizers in traditional agriculture.

The highest value of organic food is related to the fact that it is safe for health, contains more vitamins, minerals and other nutrients; it is also free from harmful chemicals, which are used as food, flavor additives and preservatives in processed food and has a beneficial effect on the overall human health (http://old.minagro.am/).

It is worth mentioning that SHEN NGO is the first in Armenia to start organic farming to create a new, sustainable and environmentally friendly source of income for rural households (https://shen.am/hy/node/1324). In 2019, Shen NGO donated a previously certified land plot in Akunk village, Kotayk region to ANAU. In the mentioned plot organic cultivation of fruit trees is carried out and, hence, it was fit for our research activities.

Materials and methods

The research was conducted in 2020-2021, during the vegetation period, the aim of which was to study the species composition of pests in Akunk Organic Agricultural Experimental Farm against the background of biological struggle.

Pear and apple trees were the study objects. The works

were carried out during the whole vegetation period through observations, investigations and sampling. Trees were viewed from all geographical locations according to tiers. The scaffold branches, bark, leaves of trees, the fruits both dropped and those on the tree, the plant remains under the trees and after harvest, the tree wastes and mummified fruits were all examined. The collected samples were taken to the laboratory, where the species composition of harmful organisms was identified.

The collection and fixation of harmful organisms was carried out according to the methods accepted in entomology and phytopathology (Dobrozrakova, 1974, Dementyeva, 1985, Forecast of the Appearance and Registration of Pests and Diseases of Agricultural Crops, 1959).

Results and discussions

As a result of our research concerning the apple and pear trees in Akuk Organic Agriculture Experimental Orchards, 24 species of harmful organisms have been registered, out of which 17 are insects, 1 is a tick and 6 are diseases. The harmful organisms detected in the Akunk orchards with their harm symptoms are presented in Table 1 and 2.

In figures 1 and 2, the photos of pests and diseases common in the apple and pear orchards of Akunq ERF are introduced.

Figure 1. Pests common in Akunk ERF and damages caused.

1. Stigmella malella (Stainton), 2. Leucoptera malifoliella (Costa), 3. Lyonetia clerkella Linnaeus, 4. Phyllonorycter corylifoliella (Hübner), 5. Phyllonorycter blancardella (Fabricius), 6. Hyponomeuta malinella, 7. Euproctis chrysorrhoea L., 8. Eriosoma lanigerum Deg., 9. Eriosoma lanigerum Hausm., 10. Stephanitis piri F., 11. Philaenus spumarius, 12. Eriophyes malinelus, 13. Hoplocampa testudinea Klug., 14. Cydia pomonella, 15. Grapholitha molesta Busch., 16. Psyylla mali Schmdbg. and Psylla pyri L., 17. Cicadatra hyalina (all photoes except the 3rd (https://en.wikipedia.org/wiki/Lyonetia_clerkella) and 16th (https://www.nexles.com/articles/apple-sucker-psylla-mali/) were taken by the authors)

Figure 2. Diseases common in Akunk ERF.

1. Apple powdery mildew, 2. Fire blight, 3. Apple scab and Pear scab, 4. Apple Mosaic virus, 5. Moniliosis, Monial burn (all photos were taken by the authors)

Table 1. Species composition of pests in apple and pear orchards of Akunk ERF*

N	Name of the pest	The nature of the damage	Year of detection
1	Stigmella malella (Stainton)-	The larvae form serpentine mines, which gradually expand. Entering the tissue of the leaf, the larvae bite holes that are visible from above in the form of spotted mines with 2 to 5 cm length. The larval secretion in the mine is in the form of a thin chain and that does not touch its side walls.	2020, 2021
2	Leucoptera malifoliella (Costa)	The larvae eat the entire parenchyma of the leaf - the spongy and horseshoe chlorophyll-bearing cells, and moving in a circle, form round mines in which the excrement is in concentric circles.	2020, 2021
3	Lyonetia clerkella Linnaeus-	The larvae form long serpentine mines, the secretion is in line, that doesn't reach the end of the mine.	2020, 2021
4	Phyllonorycter corylifoliella (Hübner)-	The mines made by larva are located at the top of the leaf blade; they are large, and due to the tension of the silk thread caused by the larva, the mines become spotty and corrugated.	2020, 2021
5	Phyllonorycter blancardella (Fabricius)	When feeding on the leaf parenchyma, the larvae produce silk fibers, which make the mine look like an oval swollen boat, and due to the partial feeding of the epidermis, the mine later becomes meshy.	2020, 2021
6	Hyponomeuta malinella-	Young larvae feed on the leaf parenchyma, reducing the leaf blade to a skeleton, and later the leaves intertwine each other with silk to form a web.	2021
7	Stephanitis piri F.	As a result of the feeding of the bug, the leaves lose their colour, gradually dry out and get a dark color. The underside of the infected leaf is contaminated with the secretions of the bug, which can be seen in black, shiny spots.	2020, 2021
8	Eriosoma lanigerum Deg.	Aphids suck the juice of buds, leaves and flower bud, as a result of which the affected organs are transformed.	2020, 2021
9	Eriosoma lanigerum Hausm.	Swelling occurs in the affected areas as a result of the feeding of the aphid.	2021
10	Psyylla maliSchmdbg.	During feeding, a sticky juice is secreted, which covers the leaves, the bud and later such leaves develop incompletely, the flower buds do not open and do not organize fruits.	2020, 2021
11	Psylla pyri L.	Damaged spring and fruits grow slowly, change shape, leaves lose their colour, are covered with psylla excrement, after some time the leaves fall.	2020, 2021
12	Euproctis chrysorrhoea L.	As a result of feeding, the larvae eat the entire leaf blade, leaving the central nerve unharmed.	2021
13	Eriophyes malinelus	A thin, smooth coating develops on the leaves, which first turns into white and then becomes yellowish-grey.	2020, 2021
14	Cydia pomonella	The larvae enter the fruit from the side part or from the cup, gnawing the flesh, they go deeper into the seminal cavity and eat the seeds.	2020, 2021
15	Meadow spittlebug	As a result of the damage, the leaves are wrinkled, the generative-vegetative organs are deformed.	2021
16	Grapholitha molesta Busch.	The larvae enter the fruit mainly from the stem, and sometimes from the contact point of the two fruits, from parts covered with leaves. Insects eat seeds.	2020, 2021
17	Hoplocampa testudinea Klug	The larvae eat the seminal cavity with seeds, filling them with rusty-red secretions, food remnant, which is visible from the outside of the fruit.	2020, 2021
18	Cicadatra hyalina	Damage is caused by cutting the stem during spawning.	2021

*Composed by the authors.

Table 2. Species composition of diseases in apple and pear orchards of Akunk ERF*

N	The name of the disease	Pathogen	Type of fruit	The infected part of the plant	Year of detection
1	Apple scab	Venturia inaequalis	Apple tree	Leaf, fruit	2020, 2021
2	Pear scab	Venturia pirina	Pear tree	Leaf, fruit	2020, 2021
3	Apple powdery mildew	Podosphaera leucotricha	Apple tree	Inflorescence, Leaf, fruit, spring	2020, 2021
4	Moniliosis, Monial burn	Monilinia fructigena	Apple tree, pear tree	Fruit, spring,	2020, 2021
5	Fire blight	Erwinia amylovora	Apple tree, pear tree	Fruit, spring, leaf	2020, 2021
6	Apple Mosaic virus	Apple Mosaic virus	Apple tree	Leaf	2021

*Composed by the authors.

Conclusion

As a result of research conducted in the apple and pear orchards of Akunk ERF we have registered twenty- four species of harmful organisms, among which 17 are insects, 1 is a tick and 6 are diseases.

The most common pests of the apple trees were *Hoplocampa testudinea Klug.* and *Cydia pomonella*, while the most widespread disease of pome fruits was *Fire blight*.

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The Study of Biological and Economic Characteristics of Some Imported Walnut Tree Varieties in Conditions of Piedmont Zone in Armenia

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ABSTRACT

The morphological investigations and yield estimation of some walnut tree varieties have been conducted in the piedmont zone of the RA Ararat valley. It has been disclosed that biological peculiarities of the imported walnut tree varieties Ideal, Chandler and Lara Peral comply with natural and climatic conditions of the piedmont zone in the Ararat valley. They provide growth and development characteristic to the mentioned varieties, and in the 10th to 12th year of the orchard establishment, 3.1-4.3 t/ha yield is produced.

Introduction

Walnut tree is a highly demanded and valuable crop among the fruit tree species. Nowadays, it has a significant production and industrial value in all agricultural zones of the Republic of Armenia.

Currently, in the developed horticultural countries only intensive dwarf and semidwarf orchards are being established (http://agris.fao.org/agris-search/), where the number of trees per the unit area increases in 2-5 times as compared to the traditional orchards. For such kind of orchards highly productive crop varieties have been bred through the selection method.

In the intensive orchards all trees are not only fruitful, but also homogeneous (with the same size and form), without any qualitative changes, which is associated with a number of privileges.

In the recent years, different walnut tree varieties have been imported into Armenia, the biological and economic characteristcs of which per the agricultural zones are not studied yet. So, it is not always feasible for the farmers to cultivate the mentioned crops, but at the same time, opportunity is created to develop and apply efficient cultivation technologies required for a specific variety.

Materials and methods

The current research aims to study and introduce high yielding, semidwarf, early-season and valuable walnut tree varieties, characterized with cluster fruiting, to the

production. The activities were implemented in conditions of the Yeghvard, Nor Yerznka and Nor Geghi communities in Kotayk region. The imported walnut varieties Ideal, Chandler and Lara Peral were selected as study objects and a comparative study was carried out.

The tree of Lara Peral is a variety of French origin, it produces yield in the second year and fructifies via lateral part of the branch. The fruits are early-ripening with 34 mm diameter, they have roundish form, white kernel and thin but hard shell. About 4-5 tons of yield per hectare is produced. The foliage is cup-like, the male flowers bloom at the end of April and the female flowers - in the first decade of May. It is susceptible to bacteriosis. The fruit weighs 11-13 grams, at the initial fruiting stage 12 kg yield per tree is produced, while at the age of 8 years, that is, in the abundant yield production period, it amounts to 19 kg. It is a tree of average growth with 5-6 m height (Firsov et all., 2015, http://agris.fao.org/agris-search/, http://www.tandfonline.com/).

The tree of Ideal is a variety of Uzbek origin with 4-5 meters height. It is a semidwarf tree, resistant towards the chlorosis, produces fruits starting from the second year and yields abundantly in the 5th year. Its fruit is large, oval with thin shell (Firsov et all., 2015, http://agris.fao.org/agris-search, http://www.tandfonline.com/).

Chandler is a medium-sized walnut variety of American origin with 5-6 meters height; it is a high-yielding, lateral fruit-bearing tree; the fruit weighs 14-16 grams and it is a mid-ripening variety. The pollinizer is the Franquette variety (Firsov et all., 2015, http://agris.fao.org/agris-search/, http://www.tandfonline.com/). The Ideal and Chandler varieties are relatively adapted to the Armenian climatic conditions.

The observations were conducted during 2015-2016 years. The experiment was set up in 3 replications and 5 trees per each replication were registered. The transitional process of varietal phenophases was investigated and the yield estimation was conducted according to the universal method developed by All-Russian Scientific Research Institute of Horticulture named after I.V. Michurin (1973) (Yesayan, 1984).

The yield data were subjected to statistical analysis through the method of dispersion analysis. The kernel/nucleus yield of the fruit was determined per 1000 gram fruit through weighing method. To determine the economic efficiency of the walnut varieties recommended for the production, the total money investments and received incomes were taken into account.

Results and discussions

The walnut varieties investigated by our research group belong to an individual group, which are characterized by botryoidal or spiked fruiting. They develop female flowers and fruits not only from the apex of that year shoots, but also from the lateral fruit buds. In the former case botryoidal, long floriferous shoot from the apical bud is developed, which produces 5-10-15 and more fruits, and in the latter case throughout the whole length of that year shoot up to its bottom part, 1-2 female flowers burst out from each bud, which get well pollinated and produce fruits. Such type of shoots also develop male flowers (Trusheva, 2014). So, self-pollination takes place, due to which they are called self-pollinating nut trees distinguished by sustainable annual fertility.

The transitional process of phenophases per years for the studied varieties is introduced in Table 1.

The results of Table 1 indicate that in the investigated walnut tree varieties defoliation starts late, while the vegetation is lingering and long-lasting. Maximum vegetation period was observed in the Chandler variety (193-200 days per years) and in the variety of Lara Peral it was 184-185 days, that is, the vegetation in this option ends up earlier.

Table 1. Developmental stages of vegetative buds in walnut tree*

Experimented options	Experimental years	Buds swelling	Shooting	Vegetative growth period	Apical bud formation	Defoliation			Vegetation duration, day
						Start	Mass	End	
Ideal	2015	07.05	12.05	12.05-08.06	13.06	25.10	06.11	21.11	194
	2016	03.05	09.05	09.05-05.06	10.06	20.10	30.10	16.11	193
Lara Peral	2015	02.05	07.05	07.05-03.06	07.06	10.10	21.10	07.11	185
	2016	28.04	04.05	04.05-06.06	10.06	05.10	16.10	01.11	184
Chandler	2015	10.05.	16.05	16.05-12.06	15.06	26.10	07.11	23.11	193
	2016	06.05	11.05	11.05-14.06	19.06	29.10	10.11	26.11	200

*Composed by the authors.

The results summed up in Table 2 disclose that all varieties are mid-ripening; the earliest mass blooming stage (May 25-30) is observed in the Lara Peral variety and the latest one (1st and 2nd decades of June) is recorded in the Ideal and Chandler varieties. The analysis of the table data testify that Lara Peral is an early mid-ripening variety, while the Ideal and Chandler varieties are mid-ripening tree varieties.

Table 2. Changes of walnut tree generative buds on the current-year shoots*

| Experimented options | Experimental years | Buds swelling | Blooming | | | Partition lignification and nucleus/kernel formation | Start of fruit maturation | Full maturation of fruit |
			Start	Mass	End			
Ideal	2015	20.05	26.05	02.06	13.06	11.07	06.08	14.09
	2016	24.05	30.05	05.06	17.06	12.07	10.08	16.09
Lara Peral	2015	15.05	20.05	25.05	07.06	08.07	25.07	05.09
	2016	17.05	24.05	30.05	14.06.	10.07.	02.08.	10.09
Chandler	2015	03.06	08.06	13.06	25.06	14.07	14.08	18.09
	2016	07.06	12.06	17.06	28.06	16.07	16.08	22.09

*Composed by the authors.

Any varietal study is aimed at the selection of high-quality and high-yielding varieties. The results of the yield capacity for the varieties studied in the current research work are introduced in Table 3. The table data show that 333 walnut trees with 6x5 m² feeding area are planted per land hectare.

The fruits of investigated varieties have thin shell and the kernel is easily removed from the lignified stratum. The fruit of Lara Peral is roundish with pointed edge and the kernel is white, while in Ideal and Chandler varieties it is longish with yellow kernel. The variety of Ideal provides high kernel yield (50-55 %). Chandler and Ideal varieties are distinguished by high yield capacity per hectare providing 3.9-4.2 t/ha yield.

Table 3. Yield capacity indices in the walnut tree varieties*

Variety name	Experimental years	Average fruit weight /without green husk/, gram	The ratio of kernel and fruit, %	Yield capacity, kg/tree	Yield capacity, t/ha
Ideal	2015	16.0		13.0	4.3
	2016	15.3	50-55	12.5	4.2
	Average	15.6		12.7	4.2
Lara Peral	2015	12.6		9.6	3.2
	2016	12.0	49-50	9.5	3.1
	Average	12.3		9.5	3.1
Chandler	2015	12.0		12.0	4.0
	2016	13.3	45-50	11.3	3.8
	Average	12.6		11.6	3.9

*Composed by the authors.

The results of yield capacity were subjected to statistical analysis through the dispersion method; LSD 0.95=0.78 t/ha, Ex%= 5.9.

The data of Table 4 indicate that the production of fruits of Chandler and Ideal variety is economically efficient; the extra profit for these options have amounted to 1125.0 and 1345.0 thousand AMD respectively. The extra yield in the Ideal and Chandler varieties have made 11.0 c/ha and 8 c/ha respectively.

Estimation of the economic efficiency enables to sum up the results of varietal studies (Table 4).

Table. 4. Estimation of economic efficiency in walnut tree varieties*

| Varieties | Yield, c/ha | Extra yield, c/ha | Extra yield cost, thousand AMD | Extra yield expenses, thousand AMD | | | | Extra profit, thousand AMD |
				Salary	Technical facilities	Other costs	Total	
Ideal	42.0	11.0	1430.0	75.0	2.5	8.5	85.0	1345.0
Lara Peral	31.0	-	-	-	-	-	-	-
Chandler	39.0	8.0	1200.0	68.0	2.0	7.0	77.0	1125.0

*Composed by the authors.

Figure.   Walnut orchard   Fertile branch   Mature fruit.

Walnut orchard and fertile branches are introduced in the relevant figure.

Conclusion

Based on the obtained results all the mentioned three varieties are recommended to the production for their further cultivation. They are all distinguished by botryoidal fruiting; besides, they are all semidwarf, early-season tree varieties with high yield capacity and are highly demanded in the market.

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The Effect of Different Pruning Types on the Growth and Yield Capacity of Plum Varieties Fortune and Vengerka Domestica in Conditions of Armavir Community in Armavir Region

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A R T I C L E   I N F O

A B S T R A C T

Pruning is vital for producing healthy and high quality yield. Nowadays, pruning of fruit and berry plants is considered to be one of the most important agro-technical measures. The role of pruning and trimming is significant in the improvement of sanitary conditions in orchards, as well as in foliage development, pest control, regular tree growth, fruiting regulation and its periodicity reduction.

In the result of our investigations it is recommended that annual medium/moderate pruning should be implemented in the orchards of Fortune plum variety and for Vngerka domestica plum variety light or moderate pruning should be implemented.

Introduction

Plum is one of the most widespread fruit species among the drupaceous fruits. It has been cultivated for more than 3000 years. In Armenia, it is the 3rd drupaceous fruit type by its significance and in case of precise varietal selection it can be cultivated in all regions. Anyhow, its industrial cultivation is centralized in piedmont zones, Ararat valley, North-Eastern regions and in the lowlands of Syunik region (Stepanyan, 2006). When establishing new orchards, it is essential to produce high-value fruit varieties by applying new technologies (Cherepakhin, 1983). Considering the plum tree as a high-value fruit bearing plant we have tried to disclose the effect of different types of pruning on the leaf

mass variations, growth stimulation and yield capacity increase in the plum varieties of Vengerka domestica and Fortune.

Tree pruning is a prior measure among the activities of orchard cultivation. It is a way to direct your tree foliage into a specific shape as it grows, using selective cutting/pruning techniques and limb positioning to achieve the desired end result upon the guidance of gaining maximum economic profit considering the peculiarities of the tree growth. Pruning activities are implemented in the orchards annually, starting from the planting year. Pruning methods can be drastically different related to the crop species, root stock strength, i.e., vigorousness, growing capacity and its peculiarities (Stepanyan, 2013). In the result of pruning

it becomes possible to increase the buds excitability for maximum yield production (Margaryan and Shahinyan, 1976).

The research results are considered as a novelty in the Armenian horticultural branch, since almost no investigations for the Fortune plum variety have been ever conducted, while the recommended pruning type for Vengerka variety enables to ensure maximum yield capacity.

a. Fortune   b. Vengerka domestica

Figure 1. Fruits of plum varieties of Vengerka domestica and Fortune

Materials and methods

The imported plum varieties Vengerka domestica and Fortune, grown in Armenia, have served as study objects (Figure 1). Cultivation of the mentioned varieties was organized in conditions of the Armavir community. The seed plants of cherry plum (Prunus cerasifera) and the seed plants of apricot tree (Armenica vulgaris) have served as rootstocks for the varieties Vengerka domestica and

Fortune respectively. The field experiments were carried out within the period of 2019-2020. The experiments were set up in 3 replications with 10 trees per each repetition. All varieties were planted upon 4x4 m feeding area with 4 m inter-row and 4 m interplant distances. The feeding area per a tree was 16 m² and there were 625 trees per hectare. The experimented trees were 10-11 years old. All the activities implemented during the experiment were aimed at the solution of the following issues: identification of the effect of different pruning types on the leaf area variation of Vengerka domestica and Fortune plum varieties, that is on the growth stimulation of the mentioned varieties and last but not least on the increase of their yield capacity.

Results and discussions

The effect of pruning intensity on the plum varieties Vengerka domestica and Fortune is introduced in Table 1. In case of light pruning the leaf area of a plum tree variety Vengerka domestica in 2019 and 2020 years made 9.20 m² and 9.54 m² respectively. In the plum tree variety Fortune lower indices of leaf area for the same years were recorded making 8.20 m² and 8.44 m² respectively. When implementing moderate pruning the leaf area of a plum tree variety Vengerka domestica made 9.03 m² and 9.48 m² and in Fortune variety – 8.11 m² and 8.14 m² in the mentioned years. In case of severe pruning the same indices for the same years in the plum variety Vengerka domestica made 8.85 m² and 8.94 m² respectively, and in the Fortune variety they were accordingly 7.68 m² and 7.89 m². Thus, in case of applying various pruning types, the average leaf mass of the trees in the plum variety Vengerka domestica exceeded the same index of the Fortune plum variety.

When applying pruning of moderate intensity in both studied varieties biological and morphological properties characteristic to the plum tree were registered per the respective leaf areas of 9.25 m² and 8.12 m² as introduced in Table 1.

Table 1. The effect of pruning intensity on the leaf area of plum tree varieties of Vengerka domestica and Fortune*

Variants	Vengerka domestica			Fortune		
	The leaf area of a tree (m²)			The leaf area of a tree (m²)		
	2019	2020	Average for 2019-2020	2019	2020	Average for 2019-2020
Light pruning	9.20	9.54	9.37	8.20	8.44	8.32
Moderate pruning	9.03	9.48	9.25	8.11	8.14	8.12
Heavy/severe pruning	8.85	8.94	8.89	7.68	7.89	7.78

*Composed by the authors.

Table 2. The effect of pruning intensity on the growth of plum tree varieties of Vengerka domestica and Fortune*

Variants	Vengerka domestica			Fortune		
	The number of shoots per tree (n)		The average number of shoots (n)	The number of shoots per tree (n)		The average number of shoots (n)
	2019	2020		2019	2020	
Light pruning	76	79	77	60	68	64
Moderate pruning	47	58	52	37	39	38
Heavy/severe pruning	26	28	27	32	42	37

Table 3. The effect of pruning intensity on the yield capacity of plum tree varieties of Vengerka domestica and Fortune*

Variants	Vengerka domestica				Fortune			
	2019	2020	The average yield capacity of tree for 2019-2020 (kg)	The average weight of fruits, 2019-2020 (g)	2019	2020	The average yield capacity of tree for 2019-2020 (kg)	The average weight of fruits, 2019-2020 (g)
	The average yield of tree (kg)	The average yield of tree (kg)			The average yield of tree (kg)	The average yield of tree (kg)		
Light pruning	104	100	102	76	32	38	35	62
Moderate pruning	43	56	49	110	17	21	19	68
Heavy/severe pruning	27	28	28	110	8	9	9	74

*Composed by the authors.

In the result of light pruning in both varieties – Vengerka domestica and Fortune – the highest indices for the average leaf area in the plum trees were recorded. While in case of heavy (severe) pruning the average leaf areas in the trees recorded the lowest values.

The effect of pruning of different intensities on the growth of the plum tree varieties Vengerka domestica and Fortune is summarized in Table 2.

In 2019-2020, as a result of light pruning implemented in the Vengerka domestica plum variety, the number of shoots developed per tree made 76 and 79 respectively. In the plum tree variety of Fortune, the number of newly developed shoots was 60 and 68 respectively.

Within the same period when implementing moderate pruning in the plum variety of Vengerka domestica, 47 and 58 shoots per tree were respectively developed, while in the plum variety of Fortune, the number of shoots made 37 and 39 in the respective years.

In case of heavy/severe pruning the number of newly developed shoots in the plum variety of Vengerka domestica made 26 and 28, while in the variety of Fortune it was 32 and 42 respectively.

In case of implementing pruning of light and moderate intensity the index of the average shoot number in both varieties exceeded the same index recorded in case of heavy/severe pruning. Particularly, in case of light and moderate pruning, the average number of shoots in the plum tree variety of Vengerka domestica made 77 and 52 respectively, while in case of severe pruning the same index was recorded as 27. For the plum tree variety of Fortune in case of respective pruning types 64 and 38 shoots, while in case of heavy pruning 37 shoots were registered.

The effect of pruning intensity on the yield capacity of plum varieties of Vengerka domestica and Fortune is summarized in Table 3. In case of light pruning implemented in 2019 and 2020, the yield capacity per tree in the plum variety of Vengerka domestica made 104 kg and 100 kg respectively. In the same years the plum variety Fortune recorded lower yield capacity, which made 32 kg and 38 kg per tree. When implementing moderate pruning, the yield capacity of the plum variety Vengerka domestica amounted to 43 kg and 56 kg during the study years, while in the Fortune variety it made 17 kg and 21 kg respectively. In case of heavy pruning the mentioned indicator in Vengerka variety made 27 kg and 28 kg, while in the Fortune variety it was 8 kg

Figure 2. Pruning of the plum tree varieties Vengerka domestica and Fortune.

and 9 kg respectively. Thus, in both plum tree varieties high yield capacity indices were recorded in case of light pruning. In the plum variety of Vengerka domestica, the average yield capacity for 2 years was estimated as 102 kg, while in the variety of Fortune the two-year average yield capacity was accounted as 35 kg. Nevertheless, when implementing light pruning, in both studied varieties small fruit size was observed. Despite the fact that higher indices for two-year average yield capacity are recorded in case of light pruning, the moderate pruning is considered as the best variant, since in that case relatively higher yield capacity (49 kg and19 kg) and high index of the average fruit weight (110 g and 68 g) is recorded.

Conclusion

Studing the pruning peculiarities of the plum tree in conditions of the Armavir community in the Armavir region the following conclusions were induced:

1. In case of implementing light and moderate pruning both studied varieties have recorded the maximum indices in the average leaf area: Vengerka domestica – 9.25 m^2, and Fortune variety – 8.12 m^2.

2. When implementing pruning of light and moderate intensity the average number of the shoots in the plum varieties of Vengerka domestica and Fortune has exceeded that of developed in case of severe pruning. When implementing severe/heavy pruning in the plum variety of Vengerka domestica 27 shoots were developed and in the Fortune variety the average number of shoots per tree was calculated as 37.

3. Out of the three pruning types (light, moderate, severe/ heavy) the moderate pruning is considered to be the best variant, since in that case relatively higher yield capacity (49 kg and 19 kg) and higher index of average fruit weight (110 kg and 68 kg) is recorded.

Based on the aforestated conclusions it is recommended that pruning of moderate intensity should be annually implemented in the orchards of Fortune plum tree variety, while in those of Vengerka domestica variety light or moderate pruning should be annually implemented. Besides, in the plantings of both investigated varieties the light pruning should be successively substituted by the heavy or moderate pruning, as in case of annual application of light pruning, the vegetative growth of the trees will significantly decline, the annual plant growth and fruiting balance will be disrupted causing premature aging of the trees. The plum varieties of Fortune should be used for further investigations.

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Calculation of the Optimal Doses of the Ameliorant Neutralizing Heavy Metals in Anthropogenically Polluted Soils

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ABSTRACT

The paper considers improvement ways of the technology for neutralizing soil polluting heavy metals. The common technologies do not yet specify the effective and environmentally friendly application doses of ameliorants absorbing the pollutants.

The theoretical calculations have proved that there is a quantitative relationship between the sizes of different fractions contained in the ameliorant and the optimal share of the ameliorant, in accordance wih the level of soil pollution. The derived relation enables to calculate the optimal shares of the ameliorants absorbing heavy metals in soil.

Introduction

One of the most important agroecological issues refers to the pollution of soil with heavy metals that not noly decreases its productivity, but also worsens the quality of the products, thus endangering the human health. Armenia is among the countries facing this problem, with the content of pollutants being 5-40 times the size of the baseline values in about 55 000 hectares of land area polluted with heavy metals (in Tavush, Lori, Syunik, Ararat and other marzes) (Amirjanyan, 1993). Therefore, reclamation of these soils is critical.

Materials and methods

The most practical way to reclaim soils polluted with

heavy metals is neutralization of the excess pollution elements in the soil. The main approach is considered to be enrichment of the soil medium with ecologically pure ameliorants substances that would either absorb the heavy metals or turn them into compounds that will be inaccessible for plants, thus reducing the opportunity to penetrate into the plant (Hayrapetyan, et al, 2008, 2009, Galstyan, et al, 2015).

However, from the standpoint of the soil's ecological purity requirement, the doses of the ameliorants entered into the soil (zeolite, dacite tuff) should be also taken control of, even if they have a natural origin and are considered ecologically clean substances. The doses of their use are still to be adjusted: based on the pollutants and the level of soil pollution, the optimal amount of an ameliorant should

be selected so that it ensures the best absorption with the minimum dose and the best grain size proportion.

In a theoretical work (Tamoyan, 2013) published on this subject, calculation of the ameliorant optimized mass and the grain size was performed based on a certain value of the grain size. However, the ameliorant used in the commercial production is actually a mixture of fractions with different grain sizes; therefore, this calculation needs to be improved.

This article considers such a generalization with the help of a simple mathematical calculation on the basis of the summability property of surfaces and masses.

Results and discussions

The amount of ameliorant to be applied to the soil to neutralize the polluting amount of heavy metals depends on a number of factors, including the content (expressed in percentage or in shares) of fractions with different grain size in the ameliorant. The ameliorant applied (zeolite, dacite tuff) is, as a matter of fact, a mixture of fractions with 0.1 mm –5 mm grain size.

The share of the grain size mass in this mixture can be presented with the help of the whole mass of the ameliorant: $m_1 = A \cdot m_{am}$, $m_2 = B \cdot m_{am}$, ... $m_i = N \cdot m_{am}$, where $A, B, ... N$ is the share of the particular fraction in the ameliorant.

With the help of the expression $S_{am} = 3 \cdot \dfrac{m_{am}}{\rho_{am} \cdot d_{am}}$ (Tamoyan, 2013) obtained for the absorption surface of separate grain size, the contribution of all grain sizes existing in the ameliorant can be calculated, while with their sum, the contribution of the whole ameliorant in absorption of heavy metals can be calculated.

At the first approximation, the efficient heavy metal-absorbing surface created by the whole ameliorant in the soil can be expressed in the form of the sum of surfaces created by different grain sizes. Mathematically, this can be presented by the following sum:

$$S_{am} = S_1 + S_2 + ... + S_i =$$
$$= 3 \cdot \frac{m_1}{\rho_{am} \cdot d_1} + 3 \cdot \frac{m_2}{\rho_{am} \cdot d_2} + ... + 3 \cdot \frac{m_i}{\rho_{am} \cdot d_i} =$$
$$= 3 \cdot \frac{m_{am}}{\rho_{am}} \left(\frac{A}{d_1} + \frac{B}{d_2} + ... + \frac{N}{d_i} \right), \qquad (1)$$

where d_i is the characterizing size of the grain (in case of spherical grain – the diameter), S_i is the absorption surface created by it, and m_{am} and ρ_{am} are the mass of the ameliorant and the density of substance, respectively.

Thus, all components of the ameliorant having (1, 2, ..., i) grain sizes create, respectively, absorption surfaces $S_1, S_2, ..., S_i$, while jointly, $S_{am} = \sum_i S_i$ efficient surface.

All atoms of any heavy metal (one chemical element) with content of m_n in soil, together, create in the environment a

$$S = \sum_n S_n = \frac{3 \sum_n m_n}{2 r_n \rho_n} \qquad (2)$$

contact surface, where m_n is the content of the particular polluting element in soil (the difference between the amount of the mobile forms of heavy metal and the maximum allowable density (MAD) for that element), ρ_n is the density of that element, and r_n is the radius of the atom (acting ionic field) (Tamoyan, 2013).

We should accept the minimum absorption area created by the ameliorant equal to the total area (optimal indicator) created by the atoms of heavy metals in the soil medium: $S_{am} = S$. In that case the alignment of (1) and (2) expressions will give:

$$m_{am} \cdot \left(\frac{A}{d_1} + \frac{B}{d_2} + ... + \frac{N}{d_i} \right) = \rho_{am} \frac{\sum_n m_n}{2 r_n \rho_n}. \qquad (3)$$

From this equation we can calculate the optimal mass of the ameliorant that is the sum of fractions of different sizes: $d_1, d_2, ..., d_i$:

$$m_{am} = \rho_{am} \frac{\sum_n m_n}{2 r_n \rho_n} \cdot \left(\frac{A}{d_1} + \frac{B}{d_2} + ... + \frac{N}{d_i} \right). \qquad (4)$$

This expression derived for a single element (heavy metal), in case of availability of different elements in the soil, should be added also according to the composition of those elements.

The proposed method needs to be further improved according to other characteristics of soil's physicochemical absorption.

Conclusion

To determine the optimal amount of ameliorant (zeolite,

dacite tuff) used to neutralize heavy metals, the following should be calculated:

a) the shares of the main fractions in the ameliorant;

b) the polluting amounts (the level of soil pollution) of heavy metals;

c) the composition of polluting heavy metals.

According to these indicators, it is possible to calculate the optimal mass of the ameliorant entered into the soil, i.e. the ecoligically substantiated share by expression (4).

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Study of Eco-Touristic Services and Forest Rehabilitation Activities in the Context of Pandemic Covid-19 and Other Affecting Factors by the Example of Hrazdan Forest Farm

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ABSTRACT

The study results have disclosed that in 2020, due to pandemic and war, only recreation and eco-touristic services estimated as 10 mln 755 thousand (30.6 % of the total) AMD were rendered against those of total 35 mln 145 thousand AMD available in Tsaghkadzor city, while the forest rehabilitation activities were underperformed by 3 hectare land area or by 33.3 %; besides, illegal logging increased by 1.8 and 2.2 ha respectively as compared to the previous two years.

So, forest ecosystem-based recreation and eco-touristic services should be integrated in the overall economic system, while at least 30 % of profit should be allocated for the conservation of forest landscapes.

Introduction

Forest and agroecosystem services are structural and system-based functions which directly or indirectly contribute to the welfare of population. Therefore, human life activity and public welfare are mainly related to both natural capital and current geo-ecosystems, which provide a base for ongoing ecosystem services from nature to social medium (Avetisyan, 2017, Concept of Creating Innovative Financial and Economic Mechanisms in the Field of Nature Protection, 2013, Galstyan and Mkrtchyan, 2013). Besides, diverse ecosystem services are vital tools for decision-making, efficient management

and legislation improvement measures in the branch of environmental protection at global, regional and local levels. Along with biodiversity, ecological balance, genetic resource, species habitat and food provision, the forest ecosystem also provides intangible, nonmaterial and physiological amenities, which people receive either from directly those systems or as a result of contacting with them (Gevorgyan, 2014, Global Carbon Project Report - Earth Syst. Sci. Data, 2015).

Thus, any research, aimed at the evaluation and promotion of forest geo-ecosystem services and forest rehabilitation activities, particularly in the context of

pandemic and Artsakh war, is actual and stems from the requirements of the strategy developed for improving forest geo-ecosystems of the Republic of Armenia (RA).

Materials and methods

For the assessment of ecosystem services, a well-known research work titled as "The Economics of Ecosystems and Biodiversity (TEEB)" (Gevorgyan, 2014) has served as a background. TEEB was approved within the framework of joint activities between German and European Committee, in 2007. In this case study an attempt was made to assess some services of forest geo-ecosystem in the Hrazdan province of the Kotayk region, which could promote the eco-tourism development in the central regions of the RA.

The studies were conducted based on the analyses and estimations of the opportunities for recreation and eco-touristic services available in the Hrazdan forest enterprise. The mentioned services rendered by the Hrazdan forest geo-systems have been assessed for the first time according to the methodology developed by A.A. Yermakova (Yermakova, 2009).

The data on the Hrazdan forest geo-systems (forest rehabilitation, care, etc.) have been retrieved from the branch of Hrazdan Forest Farm and the indices for the soils' qualitative and quantitative properties were found in the atlas of the RA soils (Atlas of Soils of the RA, 1990). During the investigations the current publications (http://www.mnp.am/, http://kotayk.mtad.am/kotayk/, http://forestcommittee.am) about the services of forest and agroecosystems in the Kotayk region have been used.

In the current research work the estimation of demographic rate per recreation resources for the Tsaghkadzor forest district has been conducted and presented as a reference example. The recreation capacity of natural complexes is interpreted as the maximum value of permissible burden for the territory of those complexes (Avetisyan, 2017, Yermakova, 2009).

Results and discussions

In the recent decade, intensive forest exploitation has considerably deteriorated the ecological balance of forest geo-system, and the most vital forest property - forest self-renewal ability – has also been disturbed.

The main goal of forest rehabilitation is the recovery of forest ecosystems by means of various strategies.

The recovery of forest-covered territories and disturbed ecosystems is particularly important for the biodiversity conservation, as well as for the improvement of forest quality and microclimatic conditions, which in their turn can ensure the sustainability of forest geo-systems.

Throughout 2019, in the Hrazdan forest farm forest rehabilitation activities on 10 ha land area were implemented, while in 2018 the mentioned activities took place along 9.8 ha land area. That is, almost the full volume of planned forest rehabilitation activities for those years was fulfilled.
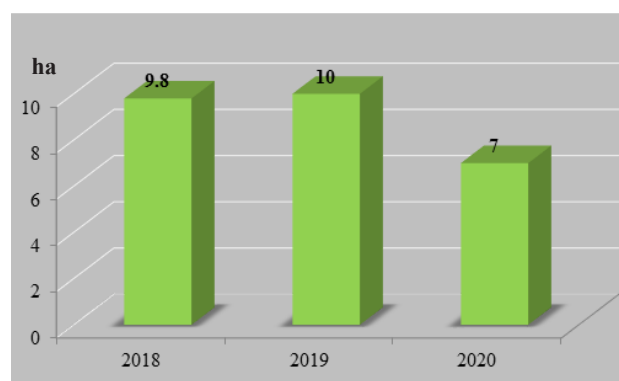
Figure 1. The volumes of forest rehabilitation activities implemented in the Hrazdan forest farm, ha (2018-2020) *(composed by the authors).*

It was planned that forest rehabilitation activities for 2020 should be implemented on 10 ha territory; anyhow, due to the Covid-19 broken out in spring and the Artsakh war unleashed in September, 2020, the planned activities were performed only in 7 ha land area, which makes 70 % of the total planned activities. Therefore, the underperformance, due to the mentioned reasons, made 30 % (Figure 1).

The branch of Hrazdan Forest Farm owns 17 ha nursery area (only 3.3 ha area is still being used). Here high quality planting materials with root-balled tree system for forest tree varieties, such as pine, birch, apple and ash trees, were grown through contemporary methods, which were later transplanted in the forest sites for forest rehabilitation and afforestation purposes.

During the forest recovery and afforestation activities implemented in autumn, 2019, about 125 thousand high quality planting materials of different tree varieties grown through root-balled tree system were used. About 250 000 planting materials with the mentioned contemporary system was grown in 2019 for their application in 2020.

In 2020, about 219 thousand saplings were produced, the majority of which was with root-balled tree system. Growing planting material with such a system is a rather efficient method, in case of which the saplings are endowed with high adaptability and survivability (99 %) (http://kotayk.mtad.am/kotayk/).

Investigating the forest recovery process in the Hrazdan forest farm (2018-2020), it has been found out that in 2018, 2019 and 2020 the employees of forest farm organized and implemented almost 100 % sanitation cutting (removal of dry and old tree branches, individual dry trees, stump shoots) in all forest districts.

Nevertheless, the situation is somehow different regarding the illegal logging recorded in the mentioned forest farm. Like in all forest farms of the republic, also in the Hrazdan forest farm, illegal logging has been recorded throughout different years.

Related to insufficient socioeconomic state of the RA population, including in Kotayk region, the illegal loggings still bear ongoing character in the forest enterprises of the republic. According to the data of State Forest Committee under the Ministry of Environment, the area of illegal loggings in the republic constitutes 35 % of the territory where forest rehabilitation activities are planned and implemented.

In 2018 and 2019, the illegal loggings in the Hrazdan forest farm (including all forest districts) made 2.2 and 1.8 ha respectively (the calculation was conducted based on the number of cut and left trees per 1 hectare land area). Based on the rates of rehabilitation activities, it should be noted that the illegal loggings in 2018 could have constituted 22.45 % of the recovered area, while in 2019 it could have been 18.0 %.

The situation is slightly different for 2020, when the illegal loggings in the forest farm was recorded on 3.95 ha land area (2000 trees and shrubs per hectare are registered according to the data of forest farm, which constitutes 56.4 % of the recovered tree nurseries in that year). This is due to the outbreak of the pandemic Covid-19 and the 44-day Artsakh war resulting in post-war socioeconomic crisis, which the great part of the RA population experienced. In this period, the socioeconomic situation of the population was exacerbated: means of sustenance, employability and fuel shortage became pressing issues.

Armenia is a unique country with its distinguished nature and clean air. Both the tourists and local people mark out several places which best comply with eco-tourism requirements. For example, all year round zipline and armchair- ropeway is operating in the Tsaghkadzor city located on the eastern slope of Mount Teghanis at an altitude of 1966-2819 m high above sea level, which is the center of tourism and downhill skiing.

According to the data provided by the Tsaghkadzor ropeway directorate, the number of visitors in winter months made 1000-1500 people per day, while in spring it made 600-800 people/day. According to the available data the overwhelming part of visitors were foreigners from Russian Federation and Islamic Republic of Iran.

These indices relate to 2018-2019 years, while in 2020 they got reduced, since the pandemic and war had a rather adverse effect on the economic and social state of both Armenian population and those of the neighboring countries. The number of visitors was mostly reduced in spring, 2020, since due to Covid-19 all air and land routes providing exit and entry to the RA, were closed.

Table. Estimation of demographic capacity in the Tsaghkadzor forest district*

Tsaghkadzor forest district	S	A	S_g	K_1	K_2	K_3	M_1	H	D_1
	47.92	80	0.6	1	1.1	1.2	0.3	2.4	70 290

*Composed by the authors.

In summer, Armenia restarted to accept visitors observing all epidemic-prevention rules, anyhow, at the end of September the Artskh war broke out, which again entailed to the reduction of visitors by about 36 %. As a result, many workplaces in the tourist companies were reduced and consequently more than 132 people were dismissed.

In the current research work demographic capacity of the Tsaghkadzor forest district per the recreation resources has been calculated. In order to determine the maximum value of permissible burden in the recreation area the following formula has been used (Yermakova, 2009):

$$D_1 = \frac{(S \cdot A + S_g) \cdot K_1 \cdot 10}{H \cdot M_1} \cdot K_2 \cdot K_3,$$

where D_1 is the demographic capacity according to the opportunity of organizing recreation in forest and riverine areas, S is the total area (km^2), A is the forest-cover (in %), S_g is the area occupied with water objects (km^2), K_1 is the coefficient of recreation organized in green zones (0.5-10), K_2 is the coefficient of availability of medical-recreational resources (1.05-12), K_3 is the coefficient of availability of touristic resources (1.05-1.2), H is a certain recreation area (2 km^2 area for 1000 native inhabitants), M_1 is the coefficient of allocating the leisure travelers throughout the forest areas and on the coasts of water areas (0.1- in case of warm climate and 0.3 – in case of temperate climate).
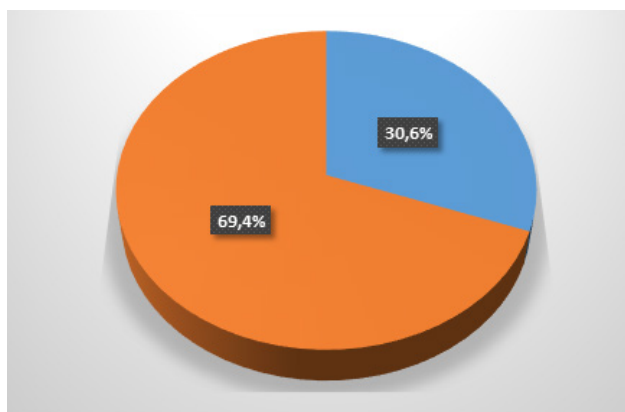
Figure 2. The index of visitors having received eco-touristic services in the Tsaghkadzor forest district against the demographic capacity of the mentioned area (data of 2020 expressed in %) *(composed by the authors).*

The results of conducted calculations are presented in the table. Per our estimations the annual demographic capacity of the Tsaghkadzor forest district is equal to 70 290 people.

In order to estimate the cost of eco-touristic services in the Tsaghkadzor forest district the number of the visitors recorded for a year has been multiplied by the entrance fee (500 AMD per capita) set.

In 2018 the number of visitors made 47 400 people, while in 2019 it accounted for 51 760 people. That is, in 2018 the cost of eco-touristic services was equal to 23 mln 700 thousand AMD, while in 2019 it equaled to 25 mln 880 thousand AMD.

In 2020, related to the pandemic of coronavirus broken out in spring and then 44-day war, started on September 27, the number of visitors sharply fell down making all in all 21 550 people. Hence, the cost of eco-touristic services was estimated as 10 mln 775 thousand AMD. Whereas the demographic capacity of the mentioned area makes 35 mln 145 thousand AMD, therefore, out of the total 35 mln 145 thousand AMD recreation and eco-touristic services available in the Tsaghkadzor city only those estimated as 10 mln 755 thousand AMD (30.6 % of the total) were rendered in 2020 (Figure 2).

Conclusion

Summing up the research results obtained about the forest eco-touristic services and forest rehabilitation activities by the example of Hrazdan forest farm the following statements can be inferred:

1. In 2018, the forest rehabilitation activities in the Hrazdan forest farm were implemented throughout 10 ha land area and in 2019 they were accomplished along 9.8 ha land area. In 2020 it was planned to implement forest rehabilitation activities again on 10 ha area, anyhow, due to the pandemic of Covid-19 broken out in spring and then the September war, the mentioned activities were conducted only on 7 ha land area, i.e., the underperformance of planned rehabilitation activities made 30 %.

2. In the period of investigations conducted in the forest farm the illegal loggings amounted to considerable quantities (%), which in 2020, again related to the pandemic and war made 3.95 ha or 56.4 % against the

recovered territory, while in the previous years (2018, 2019) the illegal loggings accounted for 2.2 and 1.8 ha respectively.

3. In 2018 the cost of eco-touristic services in the Tsaghkadzor forest district made 23 mln 700 thousand AMD, while in 2019 it was estimated as 25 mln 880 thousand AMD. Out of the total recreation and eco-touristic services estimated about 35 mln 145 thousand AMD only those with the amount of 10 mln 755 thousand AMD (30.6 % of the total) were rendered in 2020.

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Genetic Characteristics of Multiparous Goats according to the Loci of Some Polymorphous Proteins in Blood and Milk

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ABSTRACT

The issues related to the study of multiparity in agricultural animals as a prior biological property, and those to making it more manageable were raised in the scientific research field still at the beginning of previous century. To solve the mentioned issues multiple approaches and hypotheses were drawn forward in different periods, but they were very often mutually exclusive. The article considers the genetic characteristic of multiparous goats per the loci of some polymorphous proteins in the blood and milk with the aim of applying the detected genetic markers in the selection process of the branch.

Introduction

The high productivity of agricultural animals is the most significant component of animal husbandry; that is why the vector of all contemporary technologies is directed to the highly efficient use of animals' bio-economic properties, metabolism and biosynthesis.

Multiparity, as an important bio-economic property, has always been within the scope of interest of animal breeders and selectionists, and multiple investigations have been conducted in that direction. Nevertheless, not always was it possible to make it efficient and manageable, since there are still mutually exclusive opinions regarding the heredity coefficient of multiparity and nature of inheritance recorded in the professional literature sources (Lotokov, 1935, Davydov, 1936).

The use of molecular genetics and biotechnological methods in animal husbandry has enabled to consider some matters from other standpoints (Shen, et al., 2004).

It should be mentioned that such type of research works are hardly or scarcely found in the sources of professional literature, whereas, in Armenia, they are conducted for the first time.

Materials and methods

The experimental studies were conducted based on the investigations of blood and milk electrophoresis in 27 multiparous goats bred in Akhlatyan, Tolors and Brnakot communities of the Syunik region in 2020, while in 2019, they were implemented based on the same investigations in 6 multiparous goats bred in the Krashen goat breeding farm in the Shirak region.

The blood serum and homolysis have been studied through the accepted methods: in the blood serum the loci of transferrin (Tf), ceruloplasmin (Cp) and hemoglobin (Hb) (Badalyan, et al., 2018) and in milk the loci of α-lactalbumin (La), β- lactoglobulin (Lg), αS1 casein (αS1-Cn), β casein (β-Cn) have been examined (Albenzio, et al., 2009, Rout, et al., 2010, Sulimova, et al., 2007).

The investigations were carried out in the laboratory of Serology and Molecular Biology at "Scientific Center for Risks Assessment and Analysis in Food Safety Area" SNCO.

Electrophoresis was performed on 10 % polyacrylamide gel in case of blood serum proteins; while in case of milk proteins it was done on 13 % polyacrylamide gel (Osterman, 1981).

After electrophoresis, the gel was fixed in the solution for 60 minutes, after which it was painted with Kumas G250 paint for 30-60 minutes, then washed 3 times with 10 % acetic acid solution (washing buffer) (Schagger&Jagow, 1987).

The results of foregram have been analyzed through the corresponding formulae. The frequency of genotypes and alleles has been determined through the following formula:

$$P_i = \frac{n_i}{N},$$

where P_i is the frequency of i allele, n_i is the number of animals carrying the given allele, N is the total number of investigated animals.

The percentage of genotypes homozygosity for each locus has been determined through the principle of regular proportion of the total animal number under study.

The degree of homozygosity in the indicators of immunogenetic parameters of the gene pool of the population or the investigated group has been determined through the Helderman's formula (Merkureva, 1991):

$$SH = \sqrt{\frac{\sum (H_1 - H)^2}{n}},$$

where SH is the homozygosity coefficient with several loci, H_1 is the degree of homozygosity in each locus, n is the quantity of investigated loci.

Results and discussions

The analysis of electrophoresis results (Table 1) for the blood polymorphic proteins (Tf, Cp, Hb) reveals that the transferrin locus in goats is polymorphic composed of TfA, TfC and TfD alleles, the frequency of which equals to 0.18, 0.19 and 0.63 respectively; TfA allele is manifested via 2 genotypes - TfAB (0.33) and TfAC (0.18). TfC allele has formed TfCC homozygous genotype, the occurrence rate of which is equal to 11 %. As to TfD allele, it is also manifested via one homozygous TfDD genotype with 0.38 occurrence rate. The homozygosity degree of transferrin locus makes 50 %.

Table 1. Genetic structure of multiparous goats according to Tf, Cp and Hb loci*

| Locus | n | Frequency P_i | | | | | | | | | | Homozygosity degree | |
| | | Genotypes, % | | | | | | | Alleles | | | | |
		AB	AC	AD	CC	CD	DD	DF	A	C	D	According to Tf, Cp, Hb loci	According to individual loci
Tf /transferrin/	27	0.33	0.18	-	0.11	-	0.38	-	0.18	0.19	0.63		50
Cp /ceruloplasmin/	27	0.13	0.10	0.13	-	0.24	0.40	-	0.21	0.38	0.41	37	20
Hb /hemoglobin/	27	-	0.24	0.38	0.12	0.10	0.16	-	0.41	0.25	0.34		40

*Composed by the authors.

The locus of ceruloplasmin, as well as the previous one, is polymorphic composed of CpA, CpC and CpD alleles, the occurrence rate of which is equal to 0.21, 0.38 and 0.41 respectively. The ceruloplasmin allele CpA has been manifested through 3 heterozygous genotypes - CpAB (0.13), CpAC (0.10) and CpAD (0.13). The CpC allele of the same locus has come forth through CpCD heterozygous genotype, the occurrence rate of which is equal to 0.24. Regarding the CpD allele, it is worth mentioning that it has been manifested in the cytoplasmic locus via 1 homozygous genotype CpDD, the occurrence rate of which is equal to 0.40. The degree of homozygosity in ceruloplasmin locus is equal to 20 %.

The hemoglobin locus is also polymorphic composed of HbA, HbC, HbD alleles, the occurrence rate of which is 0.41, 0.25, 0.34 respectively; HbA allele has been manifested via two heterozygous genotypes - HbAC and HbAD, the occurrence rate of which makes 0.24 and 0.38 respectively. The HbC allele of hemoglobin locus has come forth via 2 genotypes (HbCC (0.12) homozygous and HbCD (0.16) heterozygous). As to HbD allele, it has formed only one HbDD homozygous genotype in the mentioned locus, the occurrence rate of which is 16 %. The degree of locus homozygosity is 40 %.

The degree of homozygosity in multiparous goats per the investigated loci of blood serum polymorphic proteins makes 37 %.

To disclose possible relations between the genetic analyses of polymorphic proteins in the goats' blood serum and their multiparity, the study results have been compared with the results of similar investigations conducted for multiparous goats of Saanen breed (Table 2).

The examined loci of transferrin, ceruloplasmin and hemoglobin in the Saanen goats were composed of A, B, D alleles, while in the local goats bred in the abovementioned communities of the Sisian province in Syunik region, they were composed of A, C, D alleles. The mentioned alleles in the Saanen goats have formed AA, AB, AC, BC, BD, DD, DF and in the local goats AB, AC, AD, CC, CD and DD genotypes.

From the genetic prospect a noteworthy similarity has been recorded related to the occurrence frequency of D allele in the Saanen goats and local multiparous goats, which is absolutely the same.

The milk loci α lactalbumin (La), β lactoglobulin (Lg), αS1 casein (αS1-Cn) and β casein (β-Cn) have been also investigated.

The data of Table 2 indicate that α lactalbumin locus (La) in the milk of the local multiparous goats is polymorphic composed of B and C alleles, the frequency of which is respectively equal to 0.60 and 0.40; B allele has been manifested through two heterozygous genotypes BC (0.33) and BD (0.28). The C allele of lactalbumin has formed one heterozygous genotype CF, the occurrence rate of which makes 0.14. The homozygosity degree of α lactalbumin is equal to zero.

The locus β lactoglobulin (Lg) is also polymorphous composed of A (0.29), C (0.31) and D (0.40) alleles. B allele has formed one heterozygous genotype BC with 19 % occurrence frequency. As regards the C allele of β lactoglobulin, it should be mentioned, that it has been manifested via 2 heterozygous genotypes CD (0.30) and CF (0.11). The D allele of the same locus has formed DD homozygous and DF heterozygous genotypes, the occurrence frequency of which is correspondingly equal to 0.18 and 0.22. The homozygosity of the locus has made 20 %.

Regarding to αS1 casein locus (αS1-Cn), it should be noted, that like other loci, it is also polymorphous consisting of B (0.63), C (0.11) and D (0.26) alleles. In the mentioned case the B allele comes forth via two genotypes BC (0.40) and BD (0.21). The C allele has formed one heterozygous CD genotype, the occurrence rate of which makes 11 %.

Table 2. Genetic structure of Saanen goats per Tf, Cp and Hb loci*

Locus	n	Frequency P_i									
		Genotypes, %							Alleles		
		AA	AB	AC	BC	BD	DD	DF	A	B	D
Tf /transferrin/	6	0.42	-	0.12	-	-	0.18	0.28	0.38	-	0.62
Cp /ceruloplasmin/	6	0.18	-	-	0.13	0.34	0.24	0.11	0.49	0.11	0.40
Hb /hemoglobin/	6	0.38	0.22	0.28	-	0.12	-	-	0.12	0.33	0.35

*Composed by the authors.

Table 3. Genetic structure of multiparous goats per La, Lg, αS1-Cn, β-Cn loci*

Locus	n	Frequency P_i									Degree of homozygosity	
		Genotypes, %						Alleles			According to αLa, βLg, αS1-Cn and β-Cn loci	According to individual loci
		BC	BD	CD	CF	DD	DF	B	C	D		
α Lactalbumin	27	0.33	0.28	-	0.14	-	0.25	0.60	0.40	-		0
β Lactoglobulin	27	0.19	-	0.30	0.11	0.18	0.22	0.29	0.31	0.40	8	20
αS1 Casein	27	0.40	0.21	0.11	-	-	0.28	0.63	0.11	0.26		0
β Casein	27	-	0.20	0.20	0.22	0.15	0.23	0.22	0.48	0.30		20

Table 4. Genetic structure of Saanen goats per La, Lg, αS1-Cn, β-Cn loci*

Locus	n	Frequency P_i								
		Genotypes, %						Alleles		
		AA	AB	AC	BB	BC	CC	A	B	D
α lactalbumin	6	0.29	0.36	-	0.35	-	-	0.38	0.62	-
β lactoglobulin	6	0.30	0.17	0.19	0.19	0.08	0.07	0.18	0.42	0.40
αS1 casein	6	0.27	0.14	-	0.11	0.45	-	0.33	0.41	0.26
β casein	6	0.48	0.26	-	0.08	-	0.18	0.21	0.49	0.30

*Composed by the authors.

As to the D allele, it is manifested through one heterozygous genotype DF (0.28) in this locus. The homozygosity of αS1 casein locus makes 0 %.

The locus β casein (β-Cn) is also polymorphous; it is composed of B (0.22), C (0.48) and D (0.30) alleles. In this case the B allele comes forth through one genotype BD (0.20). Regarding the C allele, it has been manifested via two genotypes: CD (0.20) and CF (0.22). As to the D allele, it is remarkable, that it has formed 2 genotypes (DD homozygous and DF heterozygous genotypes), the occurrence rate of which has made 0.15 and 0.23 respectively. The homozygosity of the locus has made 20 %.

The homozygosity of multiparous goats per the investigated loci of the milk polymorphous proteins is equal to 8 %.

On the whole, the degree of homozygosity per the examined loci makes 22.5 %, which is most characteristic to the local crossbred goats.

Like in case of blood polymorphic proteins' investigations, in the above presented case, one regularity is clearly recorded, when comparing the study results with the similar indices of the Saanen goat breed, i.e., there is 100 % matching in

the numerical data of D allele in the milk polymorphic proteins (Table 4).

Evidently, the D allele of both blood and milk polymorphic proteins can be considered as a genetic marker from the multiparity perspective. Thus, the obtained data can be used during the genotyping assay of the local goats and as a test in the breeding process.

Conclusion

- The investigated loci of the blood serum and milk polymorphic proteins in the multiparous goats are polymorphic.

- The homozygosity degree has made 37 % according to the polymorphous proteins of blood serum, while per the milk locus it makes 8 %.

- The data on occurrence rate of the D allele in the blood serum and milk polymorphous proteins for both the local and Saanen multiparous goats are absolutely similar, which can be considered as a genetic marker and used in the breeding procedure.

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Study of the Content of Somatic Cells in Cow's Milk in Armenia

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ARTICLE INFO

ABSTRACT

The aim of the research is to understand the quality of milk and the state of animal health in Armenia, using the Somatic Cell Counts (SCC) as an indicator. As a result, we have received a clear map of milk quality in five regions of the Republic of Armenia, the data of which are extremely alarming. According to the SCC, 12 % of 135 animals have clinical mastitis, 23 % have developed mastitis and the remaining 65 % do not have mastitis. To improve the quality of milk and the state of animal health, we suggested that processing companies apply a financial scheme of incentives and penalties to suppliers.

Introduction

One of the main preconditions for getting high quality milk is a healthy cow's udder. Milk from an animal with mastitis is not only a source of staphylococcal and streptococcal infections, but also a cause of the spread of pathogenic bacteria.

The high number of leukocytes due to the penetration of microorganisms into the udder cavity promotes the growth of somatic cells (SCC) in milk, which is the first symptom of mastitis. Separately, high numbers of SCC do not affect the quality of milk, but they "warn" of impending danger. Usually the average amount in raw milk can be in the range of 50×10^3 - 100×10^3 SCC/ml. In the case of an inflammatory lesion, the number of somatic cells increases sharply (Araksyants, 2016).

Milk quality and animal health indicators vary from country to country. According to the technical regulations of the Eurasian Economic Union (CU TC 021/2011), the permissible amount of SCC in raw milk must be 750×10^3 SCC/ml, including baby food, cheese, raw milk used for the production of sterilized milk - not more than 500×10^3 SCC/ml.

One ml of healthy cow's milk contains less than 100×10^3 SCC. When mastitis is suspected, SCC reaches 500×10^3 SCC/ml, more than 500×10^3 SCC indicates clinical mastitis (https://fsvps.gov.ru/).

Statistics on the control of mastitis and milk quality in EU dairy farms is as follows:

- A mastitis incidence rate of no more than 30 cases per 100 cows per year
- A mastitis persistence rate of no more than 20 % of the herd affected per year

- A mastitis re-occurrence rate - less than 10% of the total number of cases

- A herd-average Somatic Cell Count below $150{\times}10^3$ SCC/ml

- An average BactoScan result - below $5{\times}10^3$.

The practical tests have proven that for every $100{\times}10^3$ cells/ml increase in the herd bulk SCC, there is an 8-10 % increase in the proportion of cows infected in the herd. Persistently high individual cow SCC results can indicate chronic mastitis problems (https://ahdb.org.uk).

Materials and methods

The study was carried out in five regions of Armenia: Kurtan and Katnaghbyur villages of Lori and Azatan village of Shirak regions from the North part of Armenia, Khachaghbyur and Lusakunk villages of Gegharkunik region from the Eastern part, Geghashen village of Kotayk region from Middle part, Aragatsavan and Shenik villages of Aragatsotn region from the Western part. A total of 135 farms were selected and the sample of cow's bulk milk was taken within 2 hours at milking temperature from 6 to 8 °C to evaluate the SCC. To get accurate results, the analysis of the milk was performed in triplicate. The results of milk analyses for the content of SCC were statistically processed.

At present, SCC in milk is not measured on farms in Armenia. In case of mastitis, speed and accuracy are critical. We know that the best way to accurately measure the number of somatic cells is to count the number of somatic cells under a microscope, which can be time consuming and, in most cases, impossible to do on the farm. The DeLaval DCC somatic cell counter calculates the number of cells automatically. A digital camera takes a picture of the nuclei of somatic cells and counts them one by one. You get an accurate measurement within one minute, which enables to act as quickly as possible (https://www.journalofdairyscience.org/).

The DeLaval (DCC) Somatic Cell Meter (Made in Sweden) allows accurate testing in both laboratory and industrial settings. The disposable disc serves as a container for fresh milk during analysis. It contains a small amount of reagent mixed with milk and stains the nuclei of somatic cells. The device has a compact fluorescent microscope: camera. During the examination of each portion of milk, two photos were taken, the average result is displayed on the screen counter. The use of this device excludes the influence of the human factor on the result of the analysis, at the same time allows to study milk samples directly in the farm, as the meter is portable and is powered by a battery (www.delaval.com).

The DCC allows producers to accurately determine the SCC in milk samples obtained from each cow, in milk collected in a refrigerated container, and to closely monitor the health of cows.

Results and discussions

If SCC in 1 ml of milk does not exceed $1000{\times}10^3$ SCC/ml, then the share of milk obtained from an animal with mastitis in the total volume of milk procured is less than 6 %, that is, the dairy product is safe. However, if the SCC in the stored milk reaches $1000{\times}10^3$ SCC/ml, the volume of milk from an animal with mastitis is up to 30 % and more. Such milk is dangerous because it becomes a real source of pathogenic bacteria. It is quite natural to have a certain amount of somatic cells in milk. There is a clear link between cow production and the SCC in milk (Table 1). Productivity decreases at fairly high levels of somatic cells. As a result of doubling them, 181 L of milk is lost during 305 days of lactation of the cow (https://www.ncbi.nlm.nih.gov/).

Table 1. The state of the cow's udder by the number of somatic cells*

| Average Number of Somatic Cells, SCC/ml	Udder Condition	Milk Loss, %
Less than $100{\times}10^3$	Very good	0
$100{\times}10^3$-$300{\times}10^3$	Good	2
$300{\times}10^3$-$400{\times}10^3$	Sufficient (about 20 % of udders are diseased)	4
$400{\times}10^3$-$500{\times}10^3$	Dangerous (about 30 % of udders are diseased)	5
$500{\times}10^3$-$700{\times}10^3$	Problematic (about 40 % of udders are diseased)	Above 5
Above $700{\times}10^3$	Massive lesion (about 50 % of udders are diseased)	Above 12

*Araksyants, 2016.
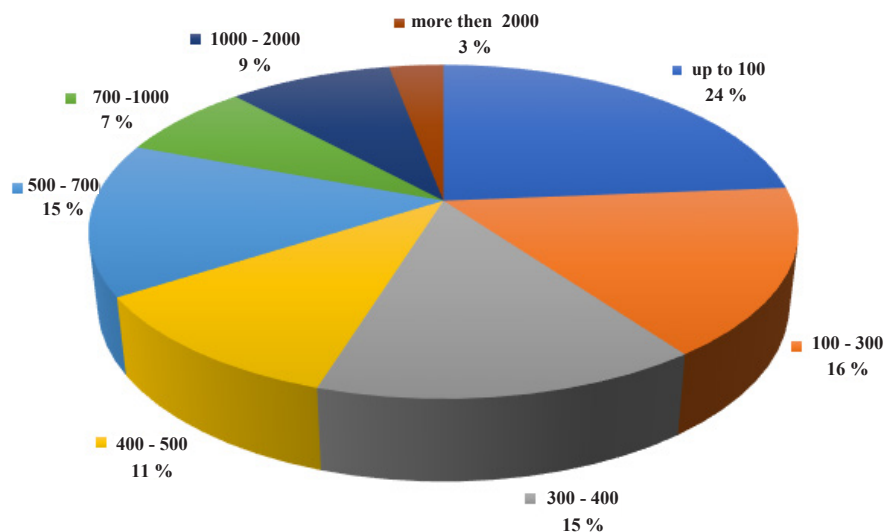
Figure 1. The content (×10³) of Somatic Cells in the milk of Kotayk, Aragatsotn, Lori, Shirak and Gegharkunik regions (*composed by the athors).*

The high SCC may be due to the breed or inheritance of the animal. Lactation also affects this indicator. Usually during the first and last weeks of lactation, the SCC increases, so the risk of udder inflammation increases. The external environment is also essential. The SCC is higher in summer than in winter, which is due to high humidity, temperature, grazing behavior of cows, exposure to fodder, and other factors. Violation of sanitary and hygienic rules, incorrect way of underfeeding, technical condition of the milking machine, general pollution of the barn, other negative factors contribute to the multiplication of bacteria. As a result, the risk of infectious diseases and the SCC increases (http://milkfacts.info/).

To identify milk produced from animals with mastitis against the overall amount of raw material production, both direct and indirect methods of somatic cell identification are used. Milk quality requirements are constantly being tightened. As an effective means, processing companies apply various financial schemes to suppliers. Therefore, the milk producer should establish daily quality control of the product. Our results are shown in Figure 1.

The SCC is a collective indicator of the sanitary quality of raw milk, according to which the price of its delivery and reception is determined. Thus, the high type in the tested milk was 40 % (no more than 100×10³ SCC/ml). The European standard is very strict compared to our requirements. The content of somatic cells in raw milk should be up to 75×10³ SCC/ml (https://ec.europa.eu/). Therefore about 24 % of the tested milk meets the above

standard. The amount of the first and second type of milk was 48 % (Figure 2). 12 % was incompatible with standard milk (CU TC 033/2013).

Processing companies should apply incentive and penalty schemes for milk delivered to suppliers. As a result of discussions with farmers and milk processing organizations of the given regions, we proposed to increase the price of milk intake by 5 AMD (Armenian currency) per liter if it corresponds to the high type and to reduce the cost of milk intake in case of the second type milk. The proposed classification of milk by type (SCC) is given in Table 2.
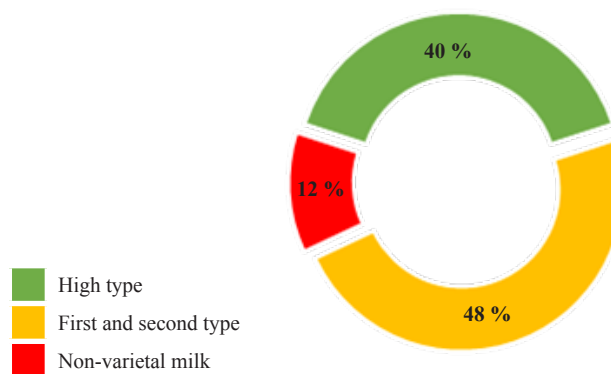
Figure 2. Types of milk from Kotayk, Aragatsotn, Lori, Shirak and Gegharkunik regions according to the content of Somatic Cells (*composed by the authors).*

Table 2. Classification of milk by types per the Somatic Cell Count*

Indicator	Milk Type		
	High	**1st**	**2nd**
The content of somatic cells 10^3 in cm^3, no more	300	500	1000
Bonus payment or discount deduction, AMD (Armenian currency)	+5	0	-5

*Composed by the authors.

Conclusion

The results of the experiments showed a very worrying picture. The high type of milk tested for somatic cells was 40 %. The amount of the first and second type of milk was 48 %. Non-varietal milk was 12 %. Farms involved in the use of somatic cell counters have taken concrete steps to treat and take preventive measures for animals with mastitis.

The use of a somatic cell metering device allows milk processors to supply higher quality milk, to ensure an increase in the yield of the finished product, and to improve the quality. The device for determining the number of somatic cells is indispensable in detecting latent mastitis and organizing its treatment. Therefore, constant monitoring of the registration and detection of somatic cells is the guarantee of getting high quality milk.

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Mastitis Incidence in First-Calf Heifers on the Small Farms of the Republic of Armenia

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ABSTRACT

The article presents the results of scientific research aimed at studying mastitis incidence in first-calf heifers and the affection of udder quarters in the mastitic first-calf heifers on eleven small farms in the Kotayk and Ararat regions of Armenia.

According to the results of scientific research, subclinical mastitis incidence in first-calf heifers made 32.3 %, while the number of affected udder quarters was 78 (per 100 animal units). The clinical mastitis was diagnosed in 10.7 % of first-calf heifers and the number of affected udder quarters was 25.

Upon the research results, the experimental farms were provided with practical recommendations on prevention of mastitis in first-calf heifers.

Introduction

Bovine mastitis is considered as N 1 problem in the contemporary dairy farming. This disease causes serious economic damage to the industry. Sharp drop in milk quality and yield is recorded due to mastitis (Parikov, 2000, Logvinov, 1992).

According to statistical data, each year 50 percent of animals are affected by the subclinical bovine mastitis, while 20-25 percent of animals manifest clinical inflammation of udder (Bogush, et al., 2001).

Mastitis may affect a cow at any age but more often it occurs in the first-calf heifers, especially during the first 3 months of lactation, and the morbidity rate of decease

is very high - up to 66.6 % - which poses threat to the animal health and often causes an untimely death of cows (Konopeltsev, 2010).

Proceeding from the above, it can be stated that the scientific research aimed at identification and treatment of the mastitis in first-calf heifers is still important nowadays (Bogush, 2009).

Materials and methods

Research activities for the assessment of mastitis incidence in brown Caucasian first-calf heifers were carried out in the laboratories of the Research Center for Veterinary Medicine and Veterinary Sanitary Examination at the

Armenian National Agrarian University, as well as on eleven small farms of the Kotayk and Ararat regions in the Republic of Armenia. Management methods of animals were stall barn housing (stabling) and grazing.

We pursued a goal in 2020, to study the incidence of clinical and subclinical mastitis in first-calf heifers, as well as identify the rate of mastitis affecting the udder quarters.

Initially, the animal housing, feeding and health conditions, as well as the lactiferous gland and secretion quality of first-calf heifers were studied on each farm. Symptoms peculiar to mastitis were identified based on the medical history and general work-up of the first-calf heifers, while the examination of udder - by milking a secretion therefrom.

The milk was tested by using 5 % dimastin solution and the special-purpose milk testing plates containing four hemispherical slots with black-and-white counterstains and circular grooves corresponding to 1 ml and 2.5 ml volumes of milk. Each slot was poured in with 1 ml milk from the respective quarter of udder and supplemented with 1 ml dimastin from the automatic beak bottle. The mixture of milk and reagent was stirred with a stick for 30 seconds. The response was recorded with crisscrosses based on the jellium density, while the color change served as a benchmarking and tiebreaking indicator. The jellium density reaction was recorded as follows: if a homogeneous liquid was produced, then the response was considered as negative (-). Where the traces of jellium were available in liquid, the response was considered as doubtful (±). Wherever coagulate was clearly visible and popped out of the slot in half or completely, the response was considered as positive (+++).

If orange or orange-red color of milk appeared upon treating with dimastin, a normal subacidic response was observed. Yellow color was an indication of increased acidity, the red color indicated an alkalinity shift, and the scarlet, carmine and magenta colors - an increased alkalinity in milk.

Upon the registration of milk test results, the content of slots was poured out into a bucket, and the plate was rinsed with clean warm water in another bucket and wiped dry with a towel.

For each testing, a list of first-calf heifers was compiled indicating the farm, date of test and cow ID number.

In order to verify the latent mastitis diagnosis, the milk taken from the udder quarter which manifested a positive response to dimastin during the test, was additionally tested for sedimentation as follows:

Upon milking the cows, 10-15 ml of milk from each udder quarter was poured into tubes and put into refrigerator for 16-18 hours at the temperature of 4-10°C. On the second day, the results were examined in the light. While examining the milk during the sedimentation test, the key attention was paid to the sediment. Healthy cows shall have white milk without any sediment. In the cows affected with mastitis a sediment was available at the bottom of test tubes, indicating their positive response for mastitis; and wherever the sediment thickness was over 0.1 cm then such cows were considered as sick.

Results and discussions

The research results demonstrated that the subclinical mastitis had affected 21 of 65 tested first-calf heifers, which makes 32.3 % if converted to 100 first-calf heifers. Seven cows (10.7 %) out of 65 had a clinical mastitis of varying severity (Table 1).

Table 1. Incidence rate of subclinical and clinical mastitis in the first-calf heifers*

Farm No.	Number of tested first-calf heifers	Positive response for subclinical mastitis		Positive response for clinical mastitis	
		Number of affected first-calf heifers	%	Number of affected first-calf heifers	%
1	5	2	40	-	-
2	15	4	26.6	2	13.3
3	6	2	33.3	1	16.7
4	3	1	33.3	-	-
5	2	1	50.0	1	50.0
6	4	2	50.0	1	25.0
7	2	-	-	-	-
8	10	3	30	1	10.0
9	5	1	20	-	-
10	4	2	50	-	-
11	9	3	33.3	1	11.1
Total	65	21	32.3	7	10.7

*Composed by the authors.

Table 2. First-calf heifers affected with subclinical and clinical mastitis per the udder quarters*

| Farm No. | Total number of tested first-calf heifers | | Subclinical mastitis | | | | | | Clinical mastitis | | | | | | |
	Number of animals	of which the number of sick animals	Fl	Fr	Hl	Hr	Total	•	Number of sick animals	Fl	Fr	Hl	Hr	Total number of udder quarters	•
1	5	2	1	-	1	1	3	60	-	-	-	-	-	-	-
2	15	4	1	2	1	2	6	40	2	1	2	2	2	7	47
3	6	2	1	2	-	2	5	83	1	1	-	1	1	3	50
4	3	1	-	1	1	1	3	100	-	-	-	-	-	-	-
5	2	1	1	-	1	1	3	150	1	1	-	1	1	3	150
6	4	2	1	-	1	2	4	100	1	-	1	1	1	3	75
7	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	10	3	2	1	2	3	8	80	1	1	1	1	1	4	40
9	5	1	1	-	1	1	3	60	-	-	-	-	-	-	-
10	4	2	1	2	2	2	7	175	-	-	-	-	-	-	-
11	9	3	2	2	3	2	9	100	1	1	-	1	1	3	33
Total	65	21	11	10	13	17	51	78	7	5	4	6	7	23	35

Note: • - affected udder quarters converted to 100 first-calf heifers. Udder quarters *(Fl - front left, Fr - front right, Hl - hind left, Hr - hind right)*

*Composed by the authors.

As it can be noticed from the data of Table 1, the minimum incidence of subclinical mastitis in first-calf heifers was detected on the ninth farm, while the maximum incidence - on the 5th, 6th and 10th farms. For clinical mastitis, the incidence was minimum (10 %) on the eighth farm and maximum (50 %) on the fifth farm. Zero incidence of both subclinical and clinical mastitis was detected on the seventh farm; and no clinical mastitis was detected on the first, fourth, seventh, ninth and tenth farms.

In the course of research, we also aimed to assess incidence of subclinical and clinical mastitis affecting the udder quarters in first-calf heifers. Research data are presented in Table 2.

Table 2 demonstrates the affection of different udder quarters during the clinical and subclinical inflammation. The number of udder quarters affected by subclinical mastitis in first-calf heifers was 78 per 100 animal units. The extreme values ranged from 40 udder quarters on the second farm to 175 quarters on the tenth farm. As regards the clinical mastitis, 35 quarters were affected (ranging from 33 to 150). The maximum affected udder quarters were observed on the 5th farm. It is apparent from Table 2, that as regards the clinical mastitis, there is a higher rate of affection of hind left and hind right quarters

(20 % and 26.5 %), which is most likely associated with the peculiarities of cows lying on their right side. These quarters closely contact with floor and they are closer to the manure passage.

Mastitis can be prevented on the farms if following the hygiene rules. However, there are diverse predisposing causes of mastitis in the first-calf heifers. As a result of our studies on housing and feeding conditions in first-calf heifers, we proposed the following preventive measures for the targeted farms: provision of clean and dry place of housing, weekly disinfection of cubicles, obligatory control of flies, timely removal of manure at least 500 m away from the farm, disinfection of udder before and after milking, wiping the teats (one wipe per each cow), scrubbing the milkers' hands with disinfecting solution, no feeding calves with mastitic milk, isolation of first-calf heifers from the sick cows, keeping the milking order (first-heifers - healthy cows - cows with sick udder) and timely treatment of wounds, injuries and lacteous gland.

Conclusion

Results of the research performed on the abovementioned farms enable to conclude that during the clinical and

laboratory tests, the subclinical mastitis incidence in the first-calf heifers made 32.3 %, and the clinical mastitis incidence - 10.7 %.

Studies revealed that the amount of udder quarters was 78 quarters per 100 first-calving heifers affected with a subclinical mastitis, and 25 quarters per 100 first-calving heifers - affected with a clinical mastitis.

Upon the examination of the first-calf heifers' housing and feeding conditions, we identified the predisposing and immediate causes of mastitis and provided the practical recommendations to the maintenance personnel of experimental farms.

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Salmonella Carrier State in Ostriches and Epizootological Situation in Ararat Region

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ABSTRACT

Salmonella carrier state of ostriches and epizootological conditions have been studied and identified for the first time in Ararat region of the Republic of Armenia.

As an endemic infectious disease, Salmonellosis has caused significant economic damage to ostrich farms. Bacteria carrying birds, caring, feeding and keeping conditions, as well as stressful situations are predisposing factors for the mentioned disease. According to the two-year epizootological investigations, under insecure conditions the indices of infection, death and lethality have made 0.2 (20 %), 0.10 (10 %), 0.53 (53 %) respectively, while the economic loss amounted to 640 000 AMD.

Introduction

Still 5000-6000 years ago humanity carried out investigations and proved that domestication of ostriches highly promotes agricultural development. The world's first ostrich farm was established in 1853, whereas the 20th century is considered to be a period for rapid development of ostrich breeding branch which became common worldwide, including in Armenia (Tarlamazyan and Hambardzumyan, 2004).

Ostriches are the largest birds in the avian world with 3 m height and 135-150 kg weight. They live in flocks. In Europe their first taming experiments were implemented in the XII century.

Since there are similarities in some properties of ostrich

and camel, the former is also called Struthio camelus (Lat. *Camelus*). The data retrieved from ancient centuries evidence that ostrich meat and brain have specific advantages over the meat products of other animals and poultry (Tarlamazyan and Hambardzumyan, 2004). Great number of ostriches was imported into Armenia in 2012-2013 (Figure 1).

Salmonellosis is a zoonotic acute infectious disease, towards which agricultural animals, poultry and humans are highly susceptible. The pathogen of this disease was first isolated by the scientists Salmon and Smith in 1855. In 1934, in honor of the scientist Salmon, bacteria of the mentioned group were named Salmonella by the international microbiology society, while the disease itself was called Salmonellosis. The genus of Salmonella

contains about 2500 serum species, which belong to the family *Enterobacteriacae* (Bessarabov, 1989, Konopatkin, et al., 1984, Grigoryan, 2002).

Figure 1. Ostrich farm in Masis city.

Serological diversity of Salmonella (*S. galinarum pulorum, S. Typhimurium, S. Enteritidis, S. Heidelberg, S. Montevideo, S. Saintpaul*) and its prevalence affects the product quality of poultry and ostrich breeding farms on the whole. It is worth mentioning that the use of the products obtained from Salmonella-affected farms is extremely dangerous for human health (Bakulov, et al., 1986, Bessarabov, et al., 2007). Human infection with food-borne pathogen is directly related to the birds infected with salmonellosis and to the food products contaminated with their pathogens (Grigoryan, 2002, Bessarabov, et al., 2007).

Individual reporters mention that ostriches are also highly susceptible towards the aforementioned serological species (Tarlamazyan and Hambardzumyan, 2004). The disease has been recorded in different countries, including Armenia, and has caused huge amounts of damages to the ostrich farms (Kudryashov and Svyatkovskiy, 2007, Akbarmehr, 2010, Grigoryan, et al., 2012).

Hence, during the case study a task was set up to investigate the salmonella carrier state in ostriches and its prevalence in Ararat region.

Materials and methods

Ostrich Salmonellosis is an enzootic infectious disease typical of young ostriches which is characterized by its acute and septic developing form, while the adult birds are bacilli carriers with chronic course of the disease (Tarlamazyan and Hambardzumyan, 2004). Environmental factors, feedstuff poor in proteins, lipids, carbohydrates, vitamins and mineral matters (calcium, phosphor salts), as well as zoo-hygienic conditions are predisposing factors for the disease development.

In 2019-2020, for the first time, Salmonella carrier state was studied and epidemiological analyses was conducted in Armenia.

The experiments were conducted in the laboratory of the ANAU Research Center for Veterinary Medicine and Sanitary Examination. Salmonella carrier ostriches were detected through autopsy findings, as well as through microbiological, biological, serological and hematological analyses (Salautin, 1989, Antonov, et al., 1986, Antonov and Blinov, 1971).

The blood, spleen, liver, kidneys, lymph nodes, intestine content, bone marrow, 40-day incubated egg, dead-in-shell (suffocated) chicks, feces and feedstuff of 8 diseased and dead ostriches aged at 3-6 months have served as study objects (Figures 2,3).

Figure 2. Incubator heating cabinet.

Figure 3. Dead-in-shell chick.

The infectivity and lethality rate (LD_{50}) of the disease pathogen was determined on 12 laboratory white mice with 14-16 g live weight through Reed-Muench method (Syurin, et al., 1984).

The antigen amount (salmonellas) was determined through bacteriological standard, which amounted to 1 ml/2 bln microbial bodies (Nurazyan, 1988).

To evaluate the qualitative and quantitative changes in the blood formed elements blood taking was implemented from the inner surface vein of the young ostriches' wings and from the cordis of mice. Morphological and antigenic properties were investigated via microscopic, microbiological and biological methods (Antonov, et al., 1986, Nurazyan, 1988, Borisovich and Kirilov, 1981, Lysak, 2007).

For microbiological research Meat-Pepton Agar (MPA), Meat-Pepton Broth (MPB), Bismuth Sulphite Agar (BSA), Endo Agar (Endo's medium), Levine's Agar and Blood Agar were used (Babich, 1963, Sargsyan and Grigoryan, 2008).

For the development of microbiological cultivars 1:5 suspender was prepared from the concentrated feed samples, while from its extract seeding with the dose of 1.0 ml was conducted in the Bismuth-Sulphite Agar, Endo Agar, MPA and MPB nutrient medium, as well as in milk. The platings were kept at 37°C thermostat conditions for 24 hours (Bakulov, et al., 1997).

More than 40 samples of Ostrich feces were taken to study the Salmonella prevalence. The feces sample taken from each ostrich was diluted through physiological solution with the ratio of 1:10 and the produced suspender was subjected to centrifugation at 3000-3500 r/m for 10-15 minutes. After washing the feces sediment for several times smears were prepared and seeding was conducted in the MPA, Bismuth-Sulphite and Endo nutrient mediums. Then the platings were kept at 37°C thermostat conditions for 24-48 hours (Bakulov, 1987).

Salmonella sensitivity *in vitro* conditions towards penicillin, cefazolin, ceftriaxone, sulfanilamide preparations and towards bicillin-3, nitox and synthomycin was investigated.

The epizootological analysis of the investigated territory was conducted per the indices of infection, death, lethality and seasonality, while the economic loss was estimated through the *El= D_o* x *C- Al* formula (Grigoryan, 2002, 2005), which is interpreted in the next section.

Results and discussions

In recent years the epizootological manifestations of Salmonella have become rather widespread in poultry and ostrich farms of some Armenian regions. It should be mentioned that 75 ostriches (two-toed ostrich) of different age are kept in the ostrich breeding farms of Masis and Edjmiatsin provinces in the Ararat region. In the result of research work monitoring, emaciation, nervousness, labored respiration, conjunctivitis, lacrimation, body tremor, temperature increase, depression, white mucuos foamy diarrhea and lack of appetite was observed in the diseased ostrich chicks. They often fall to the ground with half-open eyes and die within 2-4 days (Figure 5).

Figure 4. 3-month-old ostriches died of Salmonellosis.

Figure 5. Diseased ostrich chicks.

To find out the cause of death, dissection was carried out. As a result, blood stroke in spleen, lungs, abdomino-urinary tract, lymph nodes, caecum, small bowel and muscular gastric lining was detected (Figures 4, 6, 7, 8). Besides, the liver was deformed, enlarged and turned into

yellow-brown color, the kidneys were bruised and swallen, the gallbladder was enlarged and tense filled with bile, while the abdominal cavity was filled with blood serum fluid (Foley, et al., 2008). In adult ostriches increase in body temperature and decline in egg production capacity was recorded.

In the result of microscopic investigations gram negative, short, non-sporulating and non-capsulating immobile salmonellas with the size of 0.7-2.5 μm have been detected in the imprint smears prepared from the pathological substances, while in the Meat-Peptone-Blood Agar hemolyzed circle around the microbial colonies has been observed. In the Bismuth-Sulphite Agar black and round colonies with smooth edges have been found, in MPB turbidity and parietal ring has been recorded, while in Endo medium violet microbial colonies with smooth edges and metallic luster has been disclosed (Figures 10, 11).

The internal organs, blood, lymphatic nodes and bone marrow of the dissected young ostriches have been subjected to microscopic and microbiological examination.

The mice infected with the suspender (2 bln/1 ml) prepared from the 24-hour microbial cultivar of Salmonellosis through intra-abdominal method have recorded 83.3 % lethality, while their internal organs have been subjected to morphological and physiological modifications.

Figure 6. Blood stroke of muscular stomach lining.
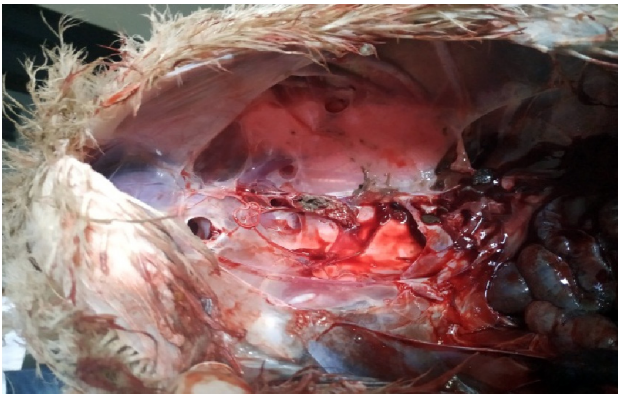
Figure 7. Intestines and lungs infected with Salmonellosis.

Figure 9. Salmonella-affected mice.

Figure 8. Blood strokes in small intestinal mucosa.

Figure 10. Salmonella growth in Bismuth-Sulphite nutrient medium.

Figure 11. Microscopic image of Salmonellas.

Figure 13. Incubated egg.

Permanently virulent salmonella strains have been isolated from the internal organs of the experimental mice (Figure 9). During the investigations 42-day incubated eggs and those intended for hatching have been examined to disclose the salmonella carrier state of ostriches (Figures 2, 3).

For bacteriological research eggs weighing 1700-2200 g were selected on the bases of similarity. Seeding from the egg shell surface, subshell membrane, egg white and yolk con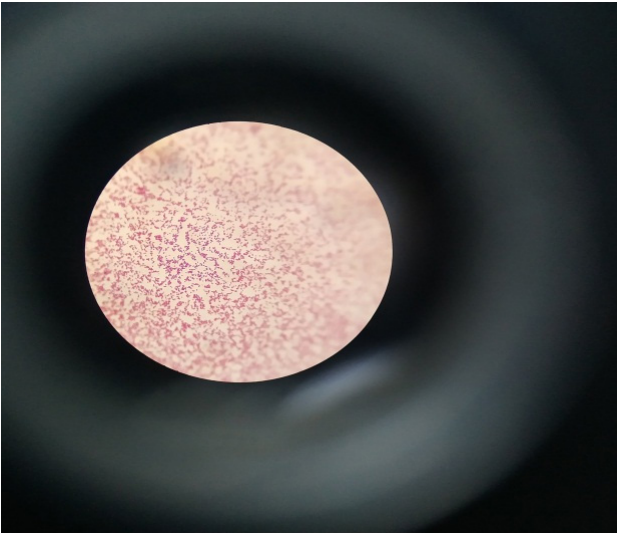tent, as well as from the organs of suffocated chicks was implemented in the abovementioned mediums. Then the platings were kept at 36-37°C for 24-48 hours (Figures 12, 13).

Figure 12. Determination of egg weight.

So, the presence of salmonellas was evaluated per the microbiological and microscopic investigations. It should be mentioned that Salmonella carrier state made 95-85 % in the clinically healthy ostriches aging 3-9 months, while in those of 3-6 years old it was 75 %. The highest index (95 %) of infectivity was recorded in 3-month old ostrich chicks.

A number of researchers distinctly report that the factors affecting the motility function of gastro-intestinal tract and gastric juice extraction are considered to be predisposing conditions for the mentioned infection (Bakulov, et al., 1984). This is often due to the abrupt change in the quality of the grain feed and its contamination with enterobacteria. In the result of microbiological examination conducted for the ostrich feed samples, a Salmonella growing tendency in the Bismuth-Sulphite Agar and Endo mediums has been also detected, while the lethality of mice infected with their microbial cultivars has made 66.6 %.

The results of microbiological investigations have shown that in the samples (internal organs, feces, egg, incubated egg) taken from the Masis ostrich breeding farms in the Ararat region Salmonella strains have been detected.

In order to retard intensive pathological changes in the bacilli carrier organisms it has been recommended to apply oxytetracycline belonging to the macrolide group of antibiotics, as well as sulfanilamide and furazolidone preparations in combined and individual forms (Grigoryan, 2002, Foley, et al., 2008).

For the disease prevention each chick was given

oxytetracycline and sulfadimethoxine together with the drinking water for 5-7 days, while furazolidone was administered via feedstuff with 30 mg/kg dosage. To increase the body reactivity, minerals, vitaminized feed supplements and digestion-improving drugs were added to feed ration (Figure 14).

Figure 14. Antibiotic test.

During the treatment qualitative and quantitative changes in the blood formed elements of the birds were determined. The disclosure of Salmonellosis symptoms is of ultimate significance for taking adequate preventive and struggling measures against the infection (Grigoryan, 2002, 2005).

Epizootological analyses for the infection, death and lethality rate were conducted considering multiple vulnerable issues peculiar to the ostrich breeding farms. The research results were subjected to statistical and comparative analyses using the relevant methodology (Grigoryan, 2005).

Thus, out of 75 ostriches 15 were infected with Salmonellosis, 8 of which died, which accounts for 0.2 (20 %) death and 0.53 (53 %) lethality rate, respectively. In addition, the economic loss caused by the Salmonella carrier state was estimated through the following well-known formula:

$$El = D_o \times C - Al = 8 \times 80000 - 0 = 640000\ AMD,$$

where El is the economic loss, D_o is the number of dead ostriches (8), C is the cost of an ostrich (8000 AMD) and Al is the actual loss.

The estimation results showed that the economic loss in the ostrich breeding farm totally made 640000 AMD.

Conclusion

The salmonella carrier state of ostriches and their epizootological conditions have been studied and analyzed for the first time in Armenia. Salmonellas have been detected in the feedstuff, internal organs, blood, eggs and feces of the dead ostriches. Stress, displacement, Salmonella carrier state, rodents, Salmonella-contaminated feed, water and zoo-hygienic conditions can be among the multiple causes of Salmonella disease and mortality of ostriches.

So, for preventive-care measures it is recommended, first, to strongly observe zoo-hygienic conditions, then to add vitamins and minerals, as well as some antibiotics with sulfanilamide preparation in the feed ration.

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The Effect of Liquid Smoke on the Quality of Uncooked Smoked Sausages

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A R T I C L E   I N F O

A B S T R A C T

Meat products are highly nutritious, shelf stable and widely consumed food products. Today, a wide range of meat products is produced in the Republic of Armenia, which differ from each other in terms of quantity and variety of raw materials, additives, heat treatment, as well as in storage and packaging conditions.

The aim of the scientific work is to reveal the threats caused upon the use of different smoking methods in the production of uncooked smoked sausages in the meat industry and to study their quality indicators.

Introduction

As it has been mentioned above, a wide range of meat products is produced in the Republic of Armenia, which differ from each other in quantity and variety of the main raw materials, additives, heat treatment, as well as in storage and packaging conditions.

Increasing production capacity is a priority for food producers today, as natural resources are declining, but at the same time the demand for meat products is increasing.

It is noteworthy that the increase of production capacity in a natural way is almost impossible and the manufacturers turn to different methods to solve this problem. Some of

these methods are: partial replacement of the main raw material with cheaper one, reduction in the duration of the technological phases in production, saving production areas and energy resources.

Of course, all these promote reduction in the cost price of final product and increase in the level of profitability, but the effect of the stated factors on the human organism is sometimes left behind the scope of researchers.

Materials and methods

Among the sausage products the uncooked smoked sausages which are produced from beef, pork, animal

fat and have a high nutritional value, long shelf life and improved organoleptic indices are of specific interest to the researchers.

Smoking is one of the most important phases in the production of uncooked smoked sausages, as a result of which the taste, smell, color and other qualitative properties of the finished product are formed (Kaim, 2006). However, it should be noted that smoking is a risk factor for quality, since during this process, substances appear on the product and its surface that can adversely affect the quality of the finished product (Feiner, 2010).

Therefore, in order to properly accomplish this process, comprehensive knowledge and skills are needed, that also require appropriate qualification of the employee. This is the main reason why the smoking process has appeared in the scope of our attention becoming a subject for scientific analysis that requires thorough investigation.

Currently, different smoking methods are used in the production of uncooked smoked sausages in Armenia, such as smoking, smoking with the use of liquid smoke, treatment with liquid smoke, etc. The latter's use significantly reduces production costs, the cost price of the finished product and enables to get finished product practically with the same organoleptic parameters in a shorter time (Fellows, 2009).

Nevertheless, the use of liquid smoke can contribute to the accumulation of such substances as benzopyrene and nitrosamines in the finished product, the content of which in finished products is regulated by Food Safety Technical Regulation 021, violation of which can even lead to criminal liability.

Nitrosamines are formed as a result of reaction between nitrates or nitrites with certain amines. Nitrosamines are found in consumer products such as processed meats, alcoholic beverages, cosmetics and tobacco smoke.

However, nitrosamines are considered to be strong carcinogenic compounds that cause cancer in various organs and tissues, such as the brain, lungs, liver, stomach, esophagus, kidneys, bladder and paranasal sinuses.

The formation of benzopyrene is due to smoking and often occurs in the animal's body via food intake due to soil contamination. Excess amount of benzopyrene contributes to the development of various types of cancer.

Results and discussions

We have developed and manufactured three samples of uncooked smoked sausages, which have been examined

per organoleptic and physicochemical indicators, as well as per the content of benzopyrene and nitrosamines.

Table 1. Samples of uncooked sausages*

N	Sample name	Smoking method
1	Sample I	Only smoking
2	Sample II	Smoking and partial liquid smoke in the stuffing
3	Sample III	Only liquid smoke in the stuffing

*Composed by the authors.

First, recipes for three samples of uncooked smoked sausages to be produced were developed, which are presented in Table 2.

Table 2. Development of recipe for uncooked smoked sausage*

N	Indicator name	Quantity, kg		
		Sample I	Sample II	Sample III
1	Beef meat without sinew, h/q	45	45	45
2	Pork fat-free	25	25	25
3	Pork fat	30	30	30
4	Table salt	0.3	0.3	0.3
5	Sodium nitrite	0.01	0.01	0.01
6	Sugar	0.2	0.2	0.2
7	Nutmeg	0.03	0.03	0.03
8	Pepper	0.1	0.1	0.1
9	Garlic solution	0.05	0.05	0.05
10	Liquid smoke	-	0.5	1
11	Cognac	0.25	0.25	0.25

* Composed by the authors.

As shown in Table 2, sample I was prepared in accordance with the requirements of the normative document (GOST 16131-86), in the second sample 0.5 % liquid smoke was added, in the third sample it was added with the amount of 1 %, which assumes, that the third sample is not subjected to wood smoking, instead, the co-formation occurs on account of liquid smoke.

In the laboratory of the Chair of Animal-Based Food

Product Processing Technology, ANAU, the organoleptic and physicochemical parameters of the three samples were determined; a tasting assessment was carried out, the results of which are presented in Tables 3, 4, 5.

Table 3. Organoleptic indices of uncooked smoked sausage samples*

Indicator name	Sample I	Sample II	Sample III
Appearance	The surface is clean, dry, without damages, spots, without depositions from the filling and broth-fat on the membrane		
Consistency	solid		
Appearance and colour in the meat cut	Homogeneous, evenly mixed mince, dark red, without grey spots and empty spaces containing pieces of pork fat not more than 3 mm in size		
Taste and smell	salty, slightly spicy, with a pronounced spice and garlic aroma, with well expressed smoking flavour, without any off-taste and off-flavour		salty, slightly spicy, with a pronounced spice and garlic aroma, with well expressed smoking flavour and bitter taste

Table 4. Physicochemical parameters of uncooked smoked sausages*

Indicator name	Sample I	Sample II	Sample III
Mass fraction of moisture, %, not more than	27.5	28.6	30.8
Mass fraction of table salt %, not more than	5.4	4.9	3.8
Mass fraction of protein, %, not less than	18.0	18.0	18.0
Mass fraction of fat, %, not more than	58	58	58
Mass fraction of sodium nitrite, %, not more than	0.003	0.003	0.003

*Composed by the authors.

As it can be seen from Table 3, the organoleptic parameters of sample I and II are almost the same, while the addition of liquid smoke in sample III promotes the appearance of a sharp and bitter taste.

The analysis of Table 4 data suggests that the mass fraction of moisture increases in samples II and III due to the reduction of smoking process in the former case and the lack of heat treatment in the latter case, resulting in the decline of salt content in the finished product which leads to the high possibility of increasing the number of pathogenic bacteria in the uncooked smoked sausage, whereby reducing their shelf life.

The three experimental samples were tasted and assessed with a 30-point scale system, the results of which are introduced in Table 5.

Table 5. Tasting results of uncooked smoked sausages*

Indicator name	Sample I	Sample II	Sample III
Tasting result, points	27 /perfect/	21 /good/	18 /satisfactory/

*Composed by the authors.

Food safety is the most vital property for food product consumers and, hence, one of the prior goals of our study was to find out the effect of various smoking methods on the safety indices of the finished food product, in particular, on the amount of nitrosamines and benzopyrene. Per the stated regulations a sample mean was produced out of the three samples and submitted to the "National Institute of Health", CJSC, after S. Avdalbekyan under the Ministry of Health of the Republic of Armenia for the quantitative determination of nitrosamines and benzopyrene. The results are shown in Table 6.

The results of the research are normalized in line with the CU TR 021/2011 Technical Regulation on Food Safety.

Table 6. The amount of nitrosamines and benzopyrene in the samples tested*

Indicator name	Sample I		Sample II		Sample III	
	Norm, not more than	Test	Norm, not more than	Test	Norm, not more than	Test
Nitrosamine /the sum of NDMA and NDEA/, gr	0.004	0.0017	0.004	0.002	0.004	0.01
Benzapyrene, µg / kg	0.001	0.0007	0.001	0.0008	0.001	0.0009

*Composed by the sanitary-hygienic testing laboratory of "National Institute of Health", CJSC, after S. Avdalbekyan

As it can be seen from the results of Table 6, the amount of benzopyrene in the three samples fluctuates, but does not exceed the requirements of the CU TR 021/2011 Technical Regulation on Food Safety, in contrast to nitrosamines, the amount of which in the third sample exceeds the norm by 0.006 g. This difference is due to the fact that the third sample was manufactured only via liquid smoke and was not subjected to standard smoking, thus, accumulating carcinogenic substances in the finished product that can cause serious harm to the human body.

Conclusion

The aim of the scientific work was to identify the threats resulted from the use of various smoking methods in the production of uncooked smoked sausages in the meat industry and to study the quality indicators. At the end of the work we can conclude:

1. The recipes of three samples for the production of uncooked smoked sausages were developed and manufactured under production conditions through different smoking methods.

2. The finished product was examined per the organoleptic and physicochemical indicators, as a result of which the adverse effect of the liquid smoke increase was proved.

3. The three samples of uncooked smoked sausages were tested according to benzopyrene and nitrosamines amount, and it has been proved that uncooked smoked sausages produced only via liquid smoke contained excess amount of nitrosamines which exceeds the norm by 0.006 g.

4. The study findings were compared with the standards of CU TR 021/2011 (technical regulations on food safety) and CU TR 034/2013 (technical regulations on meat and meat product safety).

The aforestated conclusions give ground to note that when producing any type of food products and when implementing changes in the technological processes, it is necessary to analyze risk points, because sometimes, parallel to the reduction of production phases and primecost, the manufactured food products can cause serious harms to the human organism.

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Developing and Implementing Technology of Rosé Wine Production from the Grape Variety "Charentsi"

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ABSTRACT

The research results indicate that the demand for high quality and unique wines is eventually increasing. The goal of the research was to develop and implement technologies of rosé wine production from little studied teinturier grape variety "Charentsi", for getting high-quality product according to the international standards. During the study, rosé wines were produced from the abovementioned grape varieties by applying different techniques. Besides, physicochemical and organoleptic evaluation for all wine samples were carried out.

Introduction

The production of rosé wines in Armenia is not very much developed, though Armenia has almost all required preconditions for that. The latter is partly due to the lack of demand for quality wines in the former USSR countries, where the wines produced could hardly meet the requirements of the current wine market with nowadays market conditions. Suffice it to say, that currently in developed countries the consumption level and dimensions of rosé wine has significantly increased, which can greatly encourage Armenian wineries to develop such type of wine production technologies. Rosé wine contains essential ingredients for human organism that stimulate carbohydrates, nitrogen and mineral exchange. Table wines are rich in chemical elements such as manganese, fluorine, vanadium, iodine, titanium, cobalt, potassium,

phosphorus, rubidium; the latter has a beneficial effect on the nervous system cells. (Boulton, et al., 1999, Gabrielyan, 2021).

In addition to the above noted facts, it is also noteworthy, that rosé and red wines contain various valuable substances, which are neccessary for human body. Wines contain vitamines belonging to groups B, PP, pantothenic acids and biotin. Among the volatile substances constituting the wine bouquet, there are ether oils, compound ethers, algehids and tanning agents neccessary for preserving the elasticity of blood vessels (Moreno and Peinado, 2012).

Materials and methods

The aim of the research was to develop the production techniques of rosé wine from "Charentsi" grape variety

in line with international quality standards. Based on the abovementioned we have become committed to introduce some innovations producing rosé wine from "Charentsi" grape variety which is a local crossbreed of late ripening grape variety made from "Amur x Jemchug Saba" elite seeds and "Karmrahyut" grape variety. The research also aimed to investigate the production process and its details.

In order to produce dry rosé wine from Charentsi grape variety, grape harvesting was implemented in the period of grape technical maturation, when 210 g/l average sugar content and 6-7 g/l total acidity was recorded. Raw material from the vineyards was delivered to the winery in small boxes, weighed and sent to the grape receiving hopper, where, depending on the characteristics of the grapes, potassium metabisulphite (MBSK) was added to it. The grape was destemmed and crushed by gear crushers, then processed through "pipe in pipe" type heat exchanger with the mono-pump, where the already crushed mass of grape was cooled to 12 °C.

Depending on the peculiarities of the 3 wine types, the must was separated from the crushed grape mass parallelly with 3 different methods: 1. free run must, 2. pressed fraction (up to 1.4 Bar), 3. SAIGNEE method.

It is worth mentioning that 3 subsamples were taken from each sample extracted through the mentioned methods to get precise and average statistical data. The grape musts extracted through the abovementioned methods were transferred to separate tanks, where they were kept at 15°C temperature. The further technological procedures for all 3 types of grape musts were implemented similarly; that is, the must was transferred to a tank, where the pectolitic enzymes and bentonite were added. The next day the tank was racked off, then the must was inoculated with the same type of yeast. The fermentation proceeded at the temperature of 17-18 °C. On the 3rd day of fermentation aeration was performed, during which a fermentation activator was added. The fermentation terminated with a rather low sugar indicator. After the complete fermentation, the wine was racked to a storage tank, where potassium metabisulphite was added. Storage temperature was 11-12 °C and it was periodically refilled. Then, periodically battonage (mix of wine and pure lees) was implemented. The latter makes it possible to keep the wine from being oxidized and gives it a specific flavor value.

The resulted wine samples were investigated by applying not only different physicochemical but also organoleptic (Triangle Test, Paired Comparison Test) methodologies. All applied methods are approved and guaranteed by International Organization of Vine and Wine (OIV) (OIV 2016, ISO 5495:2005, ISO 4120:2021).

Table 1. The chemical parameters of the grape samples*

Weekly measurements	Brix	PH	Total acidity, g/l	APA	Malic acid, g/l	NH$_4^+$
1	15.1	3.1	9.2	210	1.8	105.8
2	17.4	3.32	7.5	273	1.5	122.3
3	21.1	3.5	6.3	324	1.1	150.7

*Composed by the authors.

Results and discussions

In the grape and wine composition there are substances belonging to various chemical groups: carbohydrates, organic acids, phenolic and nitrogen substances, mineral elements, micro and macro elements, etc. In the course of grape processing these elements are transformed into the mash and further - to wine, as well as undergo compound transformations, thus becoming a source for creation of multiple new compounds. These transformations and the type of new compounds are related to the wine making technologies. Thus, wines produced with different technologies from the same grape variety differ in their chemical composition (Gabrielyan, 2021, Ribereau-Gayon and Dubourdieu, 2006).

The physicochemical indicators of the wine musts extracted through 3 different techniques were investigated, the results of which are introduced in Table 2. From general physicochemical viewpoint the grape musts are not drastically different from each other. Depending on certain technical peculiarities some differences were observed which cannot impact wine must quality and styling significantly.

Table 2. The chemical parameters of wine samples*

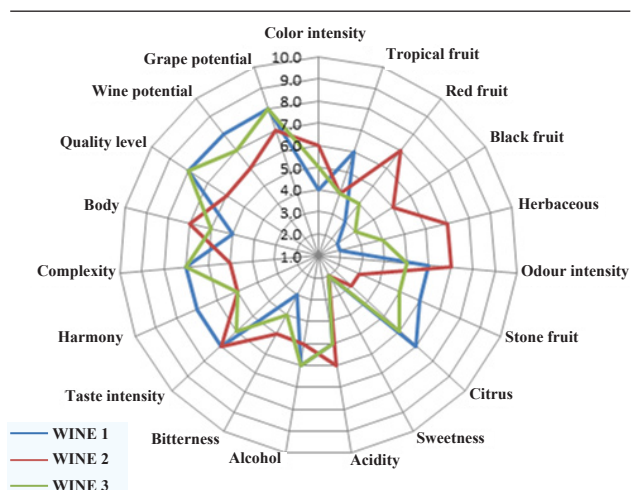| Samples	Alc., vol%	Residual sugar, g/l	pH	Volatile acidity, g/l	Total acidity, g/l
Wine 1	12.5	1.5	3.35	0.37	5.2
Wine 2	12.3	1.3	3.5	0.35	5.5
Wine 3	12.4	1.0	3.4	0.42	5.3

*Composed by the authors.

Figure. The aroma wheel of the investigated wine samples (*composed by the authors*).

Table 3. The content of total phenols in the samples*

Samples	Total phenols, mg/l
Must 1	537
Must 2	721
Must 3	584
Wine 1	392
Wine 2	516
Wine 3	458

*Composed by the authors.

Total phenol concentration in the wine must was also investigated the results of which are summed up in Table 3. It is obvious that the phenol concentration decreased after production procedures. However, relatively higher concentrations were recorded especially in rose wine.

In the wine sample 1 (wine made of free run must) the lowest concentration of total phenols was observed which can be viewed as a positive outcome for rosé wine made of such a grape variety.

After analyzing the results of Paired Comparison Test it was identified that the organoleptic indicators of the samples were different, moreover, after tasting, the majority of testers preferred the sample made of free run must.

According to Triangle Test results it can be surely stated, that the sample made of free run must was not drastically different from the one made with Saignée method, however, it is significantly different from the sample made of pressed must. Taking into consideration the demand for rosé wine flavors in the internal and external markets, the majority of testers reacted positively choosing the wine sample 1 and wine sample 3 as the best samples.

Based on the research results, the aroma wheel of the investigated wine samples was designed (Figure).

Conclusion

Hence, the results of the research show that it is possible to produce rosé wine from "Charentsi" grape variety in line with international quality and standards. The research findings prove that the wine sample made of free run must is significantly different from the other samples; it has relatively lighter coloring and body, which is the main factor accounting for its selection as the most preferable one.

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Production of Functional Cookies and Quality Research

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A R T I C L E   I N F O

A B S T R A C T

A technology for getting new assortment of functional cookies has been developed in the current work, which are intended for the use in special diets and for wide range of consumption. The quality indicators of these cookies were determined, and it turned out that the mentioned indices regulated per the standard fully meet the requirements set upon the Normative Documents. At the same time, it has been disclosed that the new cookies are enriched with iron, calcium, phosphorus, potassium, magnesium and vitamins C, B_1, B_2 and B_6.

Introduction

Currently, there are many definitions of functional food presented in the normative documents and in the professional literature (GOST R 52349-2005, GOST R 55577-2013, Decree of RF 379-2018, Loktev and Zonova, 2019). As a result of the study, the interpretation of Loktev and Zonova on "functional food" have been proved as the most acceptable. All products are functional to some extent, because they all have a certain nutritional value. Currently, food products are being intensively researched for additional physiological benefits that can reduce the risk of chronic diseases or optimize health otherwise. Due to such studies the global interest in the food types called "functional foods" has significantly increased.

Another term that is often used as a synonym for functional foods is "nutraceuticals". The term, introduced in 1991 by the Foundation for Innovations in Medicine, refers to almost any biologically active component that benefits health (Loktev and Zonova, 2019). At the present stage,

some of the most important tasks in the confectionery industry are saving expensive raw materials, expanding the product range and improving technology. It is necessary to offer the consumer qualitatively new products using non-traditional raw materials with high consumer properties and low cost. Now it is relevant to develop food recipes for specialty foods, particularly for people suffering from diabetes and obesity (Matveeva and Koryachkina, 2012). There are more than 100 officially registered confectionery enterprises in Armenia; anyhow, almost none of them produce functional confectionery for the above-mentioned purposes. The largest cookie suppliers to Armenia are from Russia, Ukraine, Poland, Germany, Spain, 80 % being from Russia. To obtain functional cookies, the powder of red currant (Ribes rubrum), growing in the RA, has been used as a source of vitamins, minerals, organic acids and pectin substances and stevioside has been used as a sugar substitute. In cookies, sugar is completely replaced with stevioside, since it enables to get a product with close-to-sucrose sweetness but that is harmless for health. The

complete replacement of sugar with stevioside is due to the fact that new products can be regularly consumed by people with diabetes, overweight and those generally taking care of their health. In 2006, The World Health Organization made a clear conclusion: the plant of "Stevia rebaudiana Bertoni" is curative and absolutely safe. Currently, "Bertoni" candyleaf herbs are also grown in Armenia. Stevioside is the main active element of candyleaf, which is an extract refined therefrom. It is a water-soluble, white, crystalline, sweet natural herbal sweetener. Stevioside is not simply a sugar substitute, but it is also a substance rich in vitamins, minerals, polyunsaturated fatty acids and has a number of advantages such as low-calorie (10 kcal); so, it is fully fit for people preferring healthy diet.

In Armenia there are 6 types of natural currants: Eastern, Alpine, Biberstein, Armenian, Akhuryan and Common. In Armenia, the Common Red Currant is widespread, which is rich in pectin, mineral substances and vitamin C (the vitamin content is 30-60 mg%) that are vital for human organism. These nutrients are elements of functional significance, and cookies prepared via their addition will be considered as functional food products.

The aim of the current work is to develop a new technology for the production of new types of sacrose-free cookies that will have functional properties and contain vitamins, useful minerals, organic acids and will be fit for general consumption, children, diabetics and overweight people.

Materials and methods

The powder manufactured from the wild-growing Common Red Current through the well-known technologies was used as an additive for the new cookies (Antipov and Zhashkov, 2010). Stevioside powder "Stivia" of the "Stevilight Fitoe" trademark was used in the manufacture of functional cookies with red currant. In the current research work, 200 g of granulated sugar was replaced with 10 g stevioside. Based on numerous preliminary experiments, the optimal dose of red currant powder was determined guided by the averaged data obtained as a result of the 5-point system evaluation. The experimental options were:

Sample 1 - butter cookies (control)

Sample 2 – functional butter cookies with 10 % red currant powder and stevioside

Sample 3 - functional butter cookies with stevioside

Sample 4 - functional butter cookies with 15 % red currant jelly and stevioside.

Cookies with berry powder and stevioside were subjected to sensory examination, besides, berry powder was added in the butter cookie with the dose of 5 %, 10 % and 15 %. Then, expert examination on the sensory indicators for the produced cookies was carried out by a degustation committee consisting of 7 people. For further examinations, the cookie scoring high point (4.8) was selected. The physical and chemical properties, content of minerals and vitamins, as well as other indices regulated per the standard of functional cookies was determined (Skuratovskaya, 2003). Laboratory examinations were conducted in the Sanitary-Hygienic Laboratory of "National Institute of Health named after Academician S. Kh. Avdalbekyan" CJSC (Ministry of Health of the RA).

Results and discussions

For the production of functional cookies, the following ingredients were used: high-grade wheat flour, red currant powder, stevioside, butter, melange, water and the mixture of $(NH_4)_2 CO_3$ and $NaHCO_3$ as baking powder. To prepare the dough, the butter and stevioside was mixed for $t=10\text{-}15$ minutes, then the other raw products fixed upon the recipe were gradually added. Currant powder is added prior to flour, so as the powder is homogeneously mixed throughout the entire dough mass. The moisture content of the dough at $T=19\text{-}22 \ °C$ made 15-24 %, after which the dough forming process was implemented. Baking lasted $t=5\text{-}12$ minutes in the oven chambers at $T=180\text{-}200 °C$, then the baked products were cooled and moved to the production tare with the help of a scraper. The degustation committee assessed functional cookies supplemented with various portions of red currant and stevioside through 5-point assessment system (per the organoleptic indicators) (Table 1).

As a result of the organoleptic examination (Table 1) the maximum rating was awarded to the functional cookie containing 10 % red currant powder. The results obtained indicate that the functional cookies with berry powders and stevioside are of high quality per their organoleptic indices and the latter are, if not always, a priority for the consumers.

The results of the physicochemical indicators of functional cookies were compared with the standard indices (GOST 24901-2014. (2019)) and it was proved that they fully meet the requirements of Normative Documents (Table 2). The chemical composition of the produced cookies was also determined: mass fractions of protein substances, carbohydrates, sucrose, fat, total ash (Table 3).

The mass fractions of minerals and vitamins C, B_1, B_2, B_6 of the studied cookies were also estimated (Table 4).

Table 1. Evaluation of functional cookies with red currant and stevioside*

Organoleptic indicators	Cookies with stevioside and different doses of red currant powder			
	control sample	5 % red currant powder	10 % red currant powder	15 % red currant powder
Appearance	1.0	1.0	1.2	1.2
Colour	0.6	0.6	1.0	1.1
Taste and flavor	1.6	1.9	2.2	1.5
Appearance in the fracture	0.4	0.4	0.4	0.5
Total	3.6	3.9	4.8	4.3

Table 2. The results of physicochemical examinations of cookies*

Samples / Indicators	Cookies				
	N1	N2	N3	N4	According to GOST-24901-2014 (2019)
Humidity, %	4.3	5.8	3.7	19.3	no more than 15.5
Mass fraction of fat in terms of dry matters, %	12.0	15.0	12.0	12.0	no less than 2.3
10% *HCL* insoluble mass of ash fraction, %	0.045	0.02	0.03	0.05	no more than 0.1
Wettability, %	160	165	160	165	no less than 150
Alkalinity, degree	2.0	1.9	2.0	1.85	no more than 2.0

Table 3. The examination results of the chemical composition of cookies*

Indicators	Cookies			
	N1	N2	N3	N4
Mass fraction of moisture, %	4.3	5.8	3.7	19.3
Mass fraction of protein, %	8.14	8.70	8.90	8.70
Mass fraction of carbohydrates, %	57.20	69.96	75.00	59.45
Mass fraction of sucrose, %	18.0	-	-	-
Mass fraction of fat in terms of dry matters, %	12.0	15.0	12.0	12.0
Total ash, %	0.40	0.55	0.40	0.50

Table 4. The content of minerals and vitamins of functional red currant cookies*

Minerals and vitamins, mg%	Cookies			
	N1	N2	N3	N4
K	106.7	212	135.6	186.3
Na	13.3	15.0	15.7	18.0
Ca	8.0	15.4	6.8	7.0
Mg	8.7	9.85	7.2	8.0
P	79.3	91.3	80.3	60
Fe	0.97	1.27	0.65	0.7
Vitamin *C*	0.0	0.1	0.0	7.0
Vitamin B_1	0.20	0.22	0.20	0.25
Vitamin B_2	0.08	0.08	0.09	0.11
Vitamin B_6	0.18	0.19	0.18	0.28
Energy value. kcal	441.4	449.7	441.6	441.4

*Composed by the authors.

The results of the examination show that functional cookies supplemented with 10 % of red currant powder and red currant jelly are richer in minerals necessary for the human body as compared to those found in standard cookies. Thus, the content of *Fe* increased by 0.3 mg%, *Na* - by 1.7 mg%, *K* - by 105.3 mg%, *Ca* - by 7.4 mg%, *P* - by 12 mg% and *Mg* - by 1.15 mg%. At the same time, they were enriched with vitamins, particularly with vitamin *C*. The content of vitamin *C* is rather high in the jelly containing samples with 15 % red currant powder. Functional cookies do not contain sucrose and the calorie content is lower compared to the standard samples (Table 4). Minerals are not only important for human food diet, but they also have a favorable effect on the bioactivities of microorganisms in the cookie dough. Interacting with the dough ingredients *Ca* and *Mg* improve the dough rheological properties.

Conclusion

As a result of the conducted experiments, sweet dough (butter), high-quality functional cookies supplemented with red currant powder and stevioside rich in minerals and vitamins have been produced.

So, functional cookies do not contain sucrose and are intended for a wide-range consumption, including children, diabetics and overweight people.

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Risk Assessment of Toxic Elements in Fruits and Vegetables Grown in Ararat Region, Armenia

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ABSTRACT

This study aims to assess toxic elements' contents in fresh fruit and vegetable, as well as related potential health risks to the adult population in the Ararat region. In the frame of the research, the transfer of toxic elements from soil to plants was evaluated and non-carcinogenic risks from food consumption were assessed. The results indicated that only in the case of apple consumption there is a low level of non-carcinogenic risk to *As* exposure. Meanwhile, in multi-food consumption and multi-element ingestion cases, the low level of risk was reported both for *As* and *Pb* exposure. Further comprehensive assessments considering more elements and additional routes of exposure are needed in the region.

Introduction

Fruits and vegetables are important nutritious components of the population's diet (FAO, 2020). Intake data available for 162 countries, indicated that the weighted mean vegetable intake was 186 g/day (Kalmpourtzidou, et al., 2020). Global fruit intake was 114 g/day (1.1 servings (100 g/day)), with highest intakes reported in Latin America (146 g/day) and lowest in the Middle East and North Africa (MENA) region (Micha, et al., 2015). According to the published data on national food balances, the per capita consumption of fruits and vegetables in the Republic of Armenia is more than 800 grams/day (Statistical Committee of the Republic of Armenia, 2020a). Therefore, continuous monitoring of these products' safety is of high priority for the population health risk assessment (Pajević, et al., 2018).

The issues related to the safety of fruits and vegetables were the subject of investigations worldwide. Numerous studies were directed to assess contamination of plants with toxic elements and associated potential risks to human health (Alam, et al., 2020, Filippini, et al., 2020, Gupta, et al., 2021, Pajević, et al., 2018, Raj and Maiti, 2020, Sanaei, et al., 2021). The contamination can occur due to natural or anthropogenic activities, which contribute to elevated levels of toxic elements in the agro-ecosystem (Pajević, et al., 2018). Investigations carried out in different countries (Chang, et al., 2014, Gupta, et al., 2021, Hu, et al., 2020, Raj and Maiti, 2020, Vrhovnik, et al., 2016) as well as in Armenia (Pipoyan, et al., 2019, 2018), revealed that fruits and vegetables have been contaminated with trace elements, particularly with lead *(Pb)*, cadmium *(Cd)*, arsenic *(As)* and mercury *(Hg)*. These are known as toxic elements causing

serious adverse health effects (e.g. neurodevelopmental effects, lung damage, kidney damage, cancer, etc.) even at low levels of exposure (Dorne, et al., 2011, Raj and Maiti, 2020). With the growing concern associated with dietary exposure to toxic elements, regulatory requirements have been set for the safety of food products including fruits and vegetables. In the Republic of Armenia, product safety is regulated by the Eurasian Economic Union's technical regulation setting the maximum allowable levels of the abovementioned toxic elements (Eurasian Economic Community, 2011).

The production of fruits and vegetables is more developed in the Ararat region of Armenia. Ararat is one of the economically developed regions of the country. The current basis of the region's economy is agriculture. As of 2019, the share of agriculture in the region's economy was 14.9 %. It is mainly specialized in viticulture, fruit-growing and vegetable-growing. The manufacture of food products (processing and canning of fruits and vegetables) and drinks is well-developed (Statistical Committee of the Republic of Armenia, 2020b). It is worth mentioning that the produced fresh fruits and vegetables, as well as processed foods, are not only consumed locally but are also being exported (e.g. to countries of the Eurasian Economic Union).

Despite the fact, that Ararat is one of the important agrarian regions and main providers of fruits and vegetables in the country, there is a lack of investigation data on food contamination with toxic elements and associated health risks, as well as the possible sources of pollution. Therefore, the goal of the present study is to assess the contents of toxic elements *(Pb, As, Cd, Hg)* in fresh fruits and vegetables, as well as associated potential health risks to the adult population of the Ararat region.

The work was supported by the Science Committee of MESCS RA, in the frames of the research project "Development of Geochemical Maps to Ensure Sustainable Agricultural Development and Food Safety" and State Program on "Environmental GeoEcological Studies".

Materials and methods

Study site, sampling and analyses

The investigated fruits and vegetables were sampled from the Ararat region which is one of the 11 administrative regions (marzes) of the Republic of Armenia. It has an area of 2 090 km^2 (7 % of total area of Armenia). The region is located in the southwest of Armenia. From the north, it has borders with Armavir region, Yerevan and Kotayk region. From the east, it is bordered by Gegharkunik

and Vayots Dzor regions. Turkey and Nakhchivan Autonomous Republic respectively form the western and southern borders of the region. Ararat is the largest region with its rural population (population de jure number is 11754) (Statistical Committee of the Republic of Armenia, 2020b).

The sampling of fruits and vegetables was done in the frame of the state monitoring program (Goverment of the Republic of Armenia, 2018) from June to October, 2019. It was implemented according to the standard operational procedures (SOPs) developed in the Center for Ecological-Noosphere Studies (CENS) using methodological guidelines of Codex Alimentarius Commission (CAC, 1993) and ISO standard on sampling (ISO 874-1980, 2017). The subsamples (at least 3) of the major cultivated and available fresh fruits and vegetables were randomly taken from agricultural plots in 13 rural communities of the Ararat region. The subsamples were mixed in a polyethylene bag to form composite samples for each fruit and vegetable. In total, 33 composite samples of 11 species of major fruits (cherry, peach, plum, grape and apple) and vegetables (watermelon, melon, green beans, tomato, cucumber and eggplant) were formed and investigated.

The sample preparation and subsequent chemical analysis of the edible parts of fruits and vegetables were done in the Republican Veterinary-Sanitary and Phytosanitary Laboratory Services Center (RVSPCLS) SNCO accredited following ISO 17025 standard. The contents of *Pb, Cd, Hg* and *As* in fruits and vegetables were determined using the atomic-absorption spectrometry (AAS, Thermo Fisher iCE-3500). The replicate analysis of each composite sample of fruit and vegetable was conducted. For the quality assurance of analysis, the Multi-Element Aqueous CRM US EPA 23 standard solution was used. The recovery ratios ranged from 95 to 98.8 % throughout the analytical procedures. The limit of detection (LOD) and limit of quantification (LOQ) are presented in Table 1.

Table 1. Limit of detection and limit of quantification*

Toxic elements	LOD	LOQ
Pb	$1 * 10^{-3}$	$5 * 10^{-4}$
As	$2 * 10^{-3}$	$1 * 10^{-3}$
Cd	$5 * 10^{-4}$	$2.5 * 10^{-5}$
Hg	$2 * 10^{-3}$	$1 * 10^{-3}$

*Composed by the authors.

Among the investigated toxic elements, Hg was not detected in all studied samples of fruit and vegetable. Besides, Cd contents were below the limit of quantification (<LOQ). Therefore, these two elements were excluded from further discussions.

Transfer factor (TF)

TF characterizing the transfer of toxic elements from soil to edible parts of fruits and vegetables was calculated with the following equation (Tasrina, et al., 2015):

$$TF = C_{plant} \times C_{soil}, \qquad (1)$$

where C_{plant} and C_{soil} are the contents of a toxic element in the plant extraction and soil, respectively.

The TFs were evaluated based on the contents of toxic elements in studied plant species and adjacent soil samples. It should be mentioned that *Cd* and *Hg* were not detected in soil samples. The data on contents of other toxic elements *(Pb, As)* in soil samples were provided by the Environmental Geochemistry Department of CENS. The soil samples were taken from the same agricultural plots where the investigated fruits and vegetables were cultivated and sampled. The contents of toxic elements in soil samples were detected using Innov X-5000 X-ray fluorescence spectrometer in compliance with the US EPA 6200 (US EPA, 2007).

Chronic non-carcinogenic risk

The potential non-carcinogenic health risk associated with chronic exposure of toxic elements was assessed calculating the hazard quotient (HQ):

$$HQ_{plant} = EDI/RfD, \qquad (2)$$

where *RfD* is the oral reference dose of toxic elements.

For *As*, RfD is equal to 0.0003 mg/kg/day, respectively (US EPA, Integrated Risk Information System, 1991). For *Pb* the provisional tolerable intake values (PTWI) were used as RfD. Before using PTWI (0.004 mg/kg/day) in calculations (EFSA, 2010), the values were divided into 7.

To assess HQs, the estimated daily intake (EDI) of each toxic element was calculated with the following equation (WHO/FAO, 2008):

$$EDI = (C \times IR)/(BW), \qquad (3)$$

where *C* is the average content (mg/kg) of toxic elements in fruits and vegetables, *BW* is the body weight (70 kg) and the *IR* is the mean daily consumption of each fruit or vegetable. The data on IR was taken from the food consumption database (Figure 1) provided by the Informational-Analytical Center for Risk Assessment of Food Chain of CENS (www.cens.am). The consumption database has been developed using food frequency questionnaire (FFQ) methodology (FAO, 2018) and the statistical treatment of the data were done using SPSS (IBM SPSS, V.22) software (Ares, 2014).

The assessed HQs were summed to calculate hazard indexes (HI) characterizing the potential non-carcinogenic risk due to the multi-element exposure and combined consumption (multi-food consumption) of investigated fruits and vegetables:

$$HI = \sum_{i=1}^{n} HQ, \qquad (4)$$

where *n* is the number of fruit and vegetable samples.

For non-carcinogenic risk characterization, the risk level description adopted by Tepanosyan et al. was used (Tepanosyan, et al., 2021). The following levels were considered: no risk (HQ < 0.1), low risk (0.1-1), medium risk (1-4) and high risk (HQ > 4).
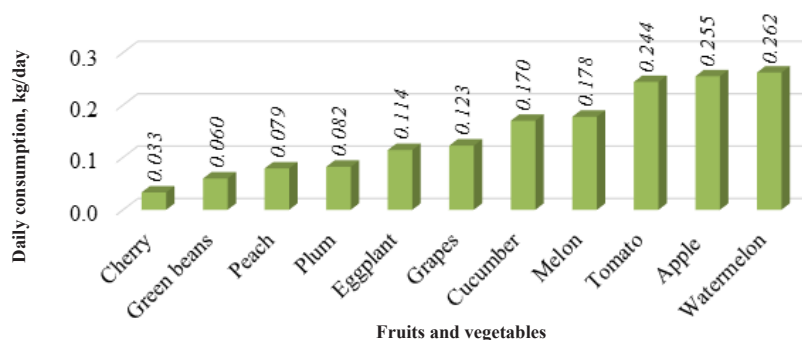

Figure 1. Daily consumption of investigated fruits and vegetables *(composed by the authors).*

Results and discussions

Toxic elements in fruits and vegetables

The contents of *Pb* and *As* in studied fruits and vegetables are presented in Table 2.

Table 2. Contents of toxic elements in selected fruits and vegetables***

Fruits and vegetables	Mean content of toxic elements (Mean ± SD, mg/kg)		
	Pb		**As**
	Allowable level (mg/kg) according to technical regulation (Eurasian Economic Community, 2011)		
	0.4*	**0.5****	**0.2**
Tomato	0.034 ± 0.008		-
Cucumber	0.032 ± 0.008		-
Green bean	0.023 ± 0.001		-
Eggplant	0.039 ± 0.004		-
Watermelon	0.035 ± 0.003		-
Melon	0.042 ± 0.011		-
Cherry	-		0.022 ± 0.013
Apple	0.039 ± 0.023		0.019 ± 0.01
Peach	0.033 ± 0.007		-
Plum	0.041 ± 0.008		0.017 ± 0.01
Grape	-		-

Note. * - for fruits, ** - for vegetables, - the content of TE in the selected samples was below the limit of detection (<LOD) or was not detected.

***Composed by the authors.

The contents of *Pb* were in the range of 0.023-0.042 mg/kg (with an average value of 0.064 mg/kg). *Pb* was not detected in samples of cherry and grape. Arsenic was detected only in 3 samples of fruits (cherry, apple and plum). Comparisons showed that the detected contents of *Pb* and *As* in all investigated fruits and vegetables were much lower than the maximum allowable levels (Table 2) set by the technical regulation on food safety (Eurasian Economic Community, 2011).

Transfer factor (TF) of toxic elements

Soil to plant transfer factor was calculated by combining the data on the content of toxic elements in plants and adjusted soils from agricultural plots in several rural communities of the Ararat region. The values are shown in Table 3.

Table 3. Soil to plant transfer factor of toxic elements*

Fruits and vegetables	TF values	
	Pb	**As**
Tomato	0.003	-
Cucumber	0.002	-
Green bean	0.001	-
Eggplant	0.003	-
Watermelon	0.003	-
Melon	0.004	-
Cherry	-	0.002
Apple	0.002	0.001
Peach	0.003	-
Plum	0.004	-
Grape	0.005	-

Note. "-" wasn't calculated, since the content of toxic element in the selected samples was below the limit of detection (<LOD) or was not detected.

*Composed by the authors.

According to some researchers (Rai, et al., 2015, Vrhovnik, et al., 2016), when TF > 1, plants undergo the bioaccumulation of trace elements from the soil. Conversely, TF < 1 indicates that the plant absorbs the element but does not accumulate it (Rai, et al., 2015, Vrhovnik, et al., 2016).

The calculated TF values are far below 1, indicating the absence of the bioaccumulation of toxic elements by the studied plant species. Similar results (TF < 1) were reported in the frame of other investigations (Jolly, et al., 2013, Pipoyan, et al., 2018, Rezaei, et al., 2019, Tasrina, et al., 2015).

Dietary exposure of toxic elements

Dietary exposure assessment was done calculating the estimated daily intake (Table 4) of toxic elements *(Pb, As)* through the consumption of fruits and vegetables grown in the Ararat region.

The obtained EDI values (Table 4) indicated that the daily intake (EDI) of toxic elements from selected fruits and vegetables didn't exceed the health based guidance values (e.g. PTWI and RfD) set by international organizations. Moreover, the same picture is observed in the case of multi-food consumption. The total EDI for *Pb* (8.26E-04 mg/kg/day) had 23.6 % contribution in the tolerable daily intake (3.50E-03 mg/kg/day). Meantime, the total EDI of *As* (9.95E-05 mg/kg/day) had the 33.2 % contribution in the oral reference dose (3.00E-04 mg/kg/day).

Table 4. Estimated daily intake (EDI) of toxic elements via fruits and vegetables consumption

Fruits and vegetables	Estimated daily intake (mg/kg/day)	
	Pb 3.50E-03 (PTWI/7)	*As* 3.00E-04 (RfD)
Tomato	1.19E-04	-
Cucumber	7.77E-05	-
Green bean	1.97E-05	-
Eggplant	6.35E-05	-
Watermelon	1.31E-04	-
Melon	1.07E-04	-
Cherry	-	1.04E-05
Apple	1.42E-04	6.92E-05
Peach	3.72E-05	
Plum	4.81E-05	1.99E-05
Grape	8.23E-05	-
Total EDIs	8.26E-04	9.95E-05

Note. PTWI/7- provisional tolerable weekly intake, RfD - oral reference dose, - wasn't calculated since the content of toxic element in the selected samples was below the limit of detection (<LOD).

*Composed by the authors.

Non-carcinogenic risk of toxic elements

In order to provide an assessment of potential non-carcinogenic health risks to adult population of Ararat region, the hazard quotients (HQ) of *Pb* and *As* were calculated (Figure 2). Moreover, the HI was calculated (Figure 3) to assess the possible health risks induced by toxic elements due to the total intake of all fruits and vegetables (multi-food consumption).

According to the RAIS methodology (The Risk Assessment Information System, 2020), the non-carcinogenic risk (HQ and/or HI) greater than 1 indicates that an adverse health effect could be expected, while the range of 0.1-1 indicates that some precautionary measures should be considered. If HQ/HI < 0.1, then there is no possibility of an adverse health effect. The results (Figure 2) of the current study showed that the calculated HQ values for each product (except for apple) are significantly below the precautionary level (HQ < 0.1). However, in the case of apple consumption, the low level of non-carcinogenic risk to *As* exposure was observed. When considering the multi-food consumption scenario, the hazard indexes of both *Pb* and *As* (Figure 3) exceeded the precautionary level of 0.1 indicating a low level of chronic non-carcinogenic health risk for the adult population in the Ararat region. In the
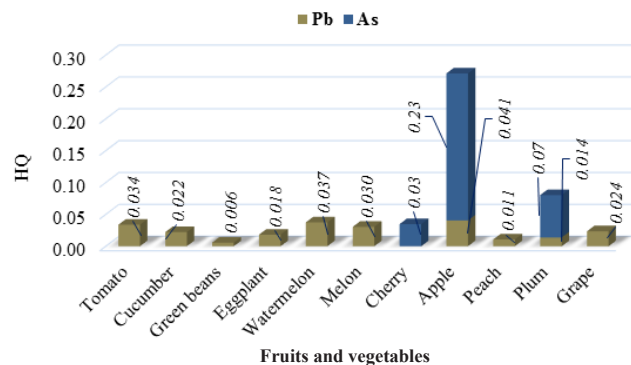

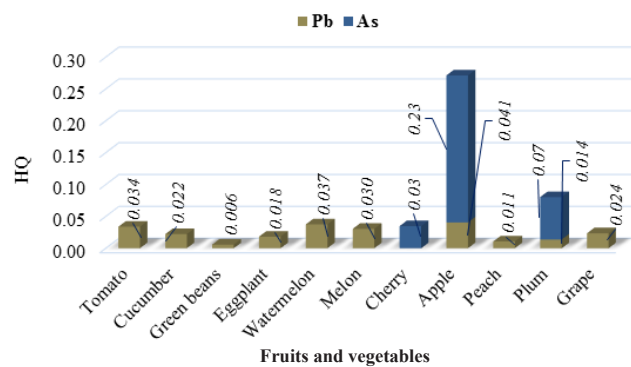**Figure 2.** Daily consumption of investigated fruits and vegetables *(composed by the authors).*

Figure 3. Hazard index (HI) of *Pb* and *As* in case of multi-food consumption *(composed by the authors).*

case of the multi-element exposure due to the multi-food consumption, the HI is equal to 0.568. This constitutes 57 % of the safety threshold of 1.

Conclusion

The study represents the first step to assess dietary exposure to toxic elements in one of the important agrarian regions of Armenia - Ararat. Among the studied toxic elements only for *Pb* and *As* the detected contents were reported. At the same time, it was found out that the selected fruits and vegetables grown in different rural communities in the Ararat region are not bio-accumulators of *Pb* and *As*. However, the local adult population's health risk assessment results showed some concerns associated with these toxic elements. The outcomes indicated that the total daily intakes of *Pb* and *As* resulting from the multi-food consumption, contribute a considerable proportion (23.6 % and 33.2 %, respectively) of the tolerable daily doses.

Overall, the study outcomes highlighted that even with the allowable contents of the toxic elements, the consumption of the selected fruits and vegetables can pose low level of chronic non-carcinogenic risk to the adult population in the Ararat region. To conclude, further comprehensive assessments considering more elements and additional routes of exposure are needed in the region. Moreover, the changes in the consumption of the studied fruits and vegetables can be also considered as one of the possible options for the risk mitigation.

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Food Powder Manufacture from Grape Pomace and its Application as an Improver in the Macaroni Production

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ABSTRACT

A number of dietary and functional food products are manufactured by macaroni producing enterprises, which are presented in trade network, but their percentage ratio is still small.

Nutritional and biological value of macaroni products can be enhanced due to the introduction of non-traditional raw materials and specific food additives in the recipe.

Based on this, a concept for developing high quality and nutrient value macaroni production technology is recommended, which is related to the selection of non-traditional raw material. The novelty of the research is that the grape pomace powder is going to be used as an additive with high nutritional value.

Introduction

Food quality and balanced diet of a person have a crucial role in the health care and life quality of humanity. Pasta products are in great demand among all groups of population, and hence, they can be considered as an object for being enriched with functional ingredients.

A number of food products supplemented with dietary or functional components are manufactured by macaroni producing enterprises, which are introduced in the trade network but their amount is rather small in percentage ratio. Taking into account the high demand for macaroni products, the opportunity of including non-traditional raw materials for the change of food chemical composition and increase of its nutritional value can be considered

as a perspective direction (Avetisyan, 2015). The food nutritional and biological value can be enhanced by including non-traditional raw materials and specific food additives in the recipes. The aim of the current work is to improve the technology of producing food powders from the grape husks and seeds and to apply them in the technology for manufacturing high nutrient value macaroni products.

Materials and methods

Pasta products possess several advantages over the other flour products, i.e. high digestibility of the essential nutrients, long shelf life, low cost and availability for any population strata.

The investigations have shown that poor chemical composition of the pasta produced from the bread flour characterizing their nutritional value, points to the need for supplementing the mentioned products with such foodstuffs, as protein, essential amino-acids, food fibers, vitamins and mineral substances.

Therefore, a concept for developing a technology for producing high quality macaroni product with high nutritional value has been recommended based on the selection of non-traditional raw material type. It aims to justify the use of grape pomace food powder as a plant-based raw material in the pasta production with high biological value, to determine their effect on the wheat flour and to evaluate the application efficiency of grape pomace powder in enhancing the qualitative properties of the new type of macaroni products (Sedrakyan, 2017).

Studying different literature sources, we have found out that the grape pomace is one of the prior sources for food powder manufacture, which contains up to 20 % cellulose and 5-8 % pectic substances and which is not practically processed in the primary wineries (Perkovets, 2008).

Upon the study of chemical composition of grape pomace, it has been disclosed that its dry mass contains monosaccharides (4.03 %), lignine (soluble, 28.4 %), water-soluble polysaccharides (6.56 %), hemicelluloses (A, B) and nitrogenous bases (0.22 %).

Carbohydrates manifested through mono- and disaccharides, pectic substances and cellulose are the main components of the grape pomace. Cellulose together with insulin decreases the blood glucose level.

Food fibers reduce the food digestibility and increase the energy consumption during metabolism enabling to decrease the weight of the people suffering from obesity.
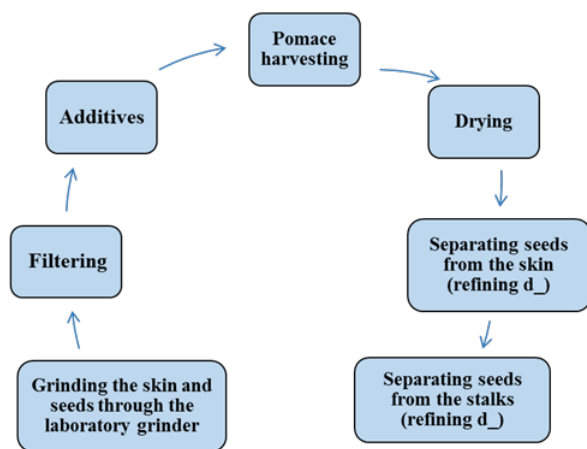
The technological scheme of producing grape pomace powder was developed in laboratory conditions, which is introduced in Figure 1.

After producing food powder from the pomace of thered grape varieties (Kakhet, Kangun, Rkatsiteli), its chemical composition was determined and evaluated, which is presented in Table 1.

Table 1. Chemical composition of the food powders produced from the red grape pomace*

Indicator	Pomace variety		
	Kakhet	Kangun	Rkatsiteli
Mass composition of carbohydrates, %, including	64.8	71.4	60.9
Pectic substances, %	6.3	8.3	7.8
Cellulose, %	16.8	20.8	19.4
Mass composition of acids, %	8.2	6.8	9.3
Tannins and dyestuffs, %	2.1	0.2	0.3
The content of mineral substances			
Iron, mg %	18.31	11.25	12.88
Manganese, mg %	1.36	1.08	1.25
Zink, mg %	3.37	6.2	5.8
Copper, mg %	2.1	1.5	1.2
Iodine, mcg %	36	30	28
Sodium, mg %	7.85	10.25	9.81
Potassium, mg %	812.5	760.4	770.1
Calcium, mg %	83.3	77.7	63.3
Magnesium, mg %	91.3	72.8	68.9
Content of vitamins, mg %			
C	17.6	14.1	12.3
β-carotene	18.9	16.1	14.8
B6	0.09	0.07	0.06

*Composed by the authors.

Figure 1. The scheme of producing powder from the grape pomace *(composed by the authors).*

As it is shown in Table 1, the main constituents of the produced supplement are carbohydrates coming forth as pectic substances and cellulose. The grape pomace powders contain a large number of vitamins and mineral substances which penetrate in all live cells and structural tissue particles, as well as in the biologically vital ferments and take part in metabolism. Special attention should be paid to the high content of dietary fibers in the grape pomace powder, which have fortifying effect over the flour gluten and positive impact on the human body. Nowadays food fibers are the most highly-demanded and widespread

food components due to their multifunctionality. It is well known that fibers are subdivided into water-soluble and insoluble ones. The main representative of the so-called "rigid fibers" is the cellulose, which constitutes the grape pomace.

To accomplish the task the experimental pasta sample was prepared through the following scheme including the mentioned phases (Figure 2).

Based on the conducted investigations it has been asserted that the rational cellulose portion, which mostly has positive impact on the properties of wheat flour gluten and on the quality of finished pasta products, makes 25 %.
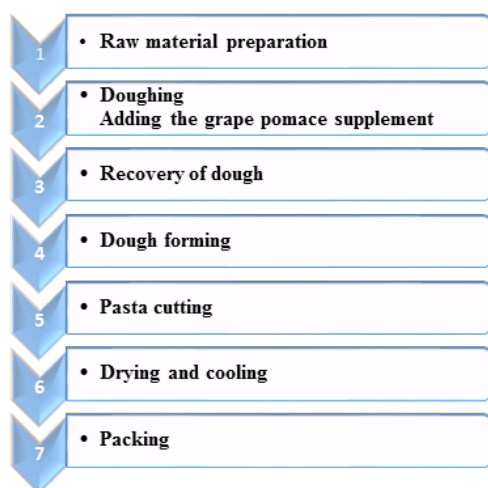

Figure 2. The scheme of experimental pasta production *(composed by the authors).*

Results and discussions

The dough without any supplement served as a control variant, while in the dough of experimental samples grape pomace with the ratio of up to 15-25 % was used. The study results related to the effect of different ratios of grape pomace on the "strength" of the wheat flour are introduced in Table 2.

The result analysis has indicated that as compared to the control variant the gluten content in the flour of experimental samples is somehow reduced in case of cellulose introduction. Besides, the elastic property of the gluten increases by 12.9 %-40.9 % in respect to cellulose ratio against the control variant. The cohesive force of the gluten grows up by 1.1 %-56.0 %. The proven effect of cellulose is due to its ability to form protein polysaccharide complexes with wheat flour proteins, which leads to an increase in its strength.

Despite the considerable elasticity increase in the gluten, its hydrating ability grows up by 2.4 % - 18.0 % against the cellulose. This is due to the physicochemical properties of food fibers, particularly to its water retention property.

Table 2. The effect of different ratios of grape pomace on the quality and quantity of the flour gluten*

Indicator name	Control	Samples with the supplementation of grape pomace powder, amount % from flour mass		
		15	20	25
Gluten content, %	29.3±0.1	28.5±0.1	28.1±0.1	27.5±0.1
Elasticity	good			
GDM* unit	64.5	56.0	53.5	54.0
Hydration capacity, %	156.25±0.75	159.8±0.75	165.1±0.75	172.5±0.75
Cohesive force, H	4.8	4.85	5.35	5.9

*Gluten Deformation Measurer *(composed by the authors).*

In mid-strength pasta producing factories the drying process is mostly implemented in the drying cabinet stations by having pasta spread in the special frames and continuously replacing the mass from one rack to another through the continuously working conveyer stations with the conveyer belt. In the drying cabinet the gradually decreasing drying temperature (heat agent) regime (from 65 ^{0}C to 35-38 ^{0}C) was applied within 5.3-5.5 hours with further stabilization within 90-120 minutes time duration. The qualitative indices of the pasta products determined in the result of the experiments are presented in Table 3.

The quality of the finished pasta products have been characterized per the strength of dry product types, their cooking properties, and per the humidity of the product after cooking. The organoleptic evaluation of the cooked macaroni products has been conducted according to the basic quality assessment scale. The analyses of the obtained results also show that when introducing fortifying additives improvement of cooking properties occur in the experimental samples as compared to those of the control variant. The cooking period which lasts up to the fabrication of the finished product insignificantly differs from that of the control sample. The experiments have confirmed that in the sample with the content of 25 % grape pomace the coefficient of pasta mass grows up. It has been also proved that in the same sample the dry matters penetrated in the boiling water are reduced. This

process is due to over-strengthening of gluten. The content of dry matters in the boiling water is reduced by 0.93 % on the average against that of registered in the control variant. The mentioned indicator is reduced by maximum amounts (by 1.12 % against the control variant) when 25 % cellulose is introduced. The quality indices of the pasta products supplemented with grape pomace are introduced in Table 4.

Table 3. Qualitative indices of the pasta products*

N	Indicators	Product Noodles
1.	Product diameter (wall thickness), mm	3
2.	Breakage, %	n/a
3.	Color	Brown with a dash of violet
4.	Surface	Smooth
5.	Humidity, %	12.8±0.2
6.	Shape retention	Retained
7.	Cooking time, until ready, minute	8
8.	Dry matter content in the boiling water, %	6.8-7.2
9.	Color index	0.40-0.44

Table 4. Quality indices of the pasta products supplemented with grape pomace powder*

Indicator	The quality indices of the pasta products manufactured through the mixture of flour and grape pomace powder, with the ratio	
	100:0 (control)	100:25
Strength of dry product, H	2.8±0.2	3.8±0.2
Cooking time, minute	7.0	8
Loss of dry matters in the boiling water, %	8.3±0.2	8.7±0.2
Coefficient of mass increase	2.89±0.03	2.96±0.03
Humidity of dry products, %	13.0±0.1	13.0±0.1
Product humidity after cooking, %	66.4±0.2	67.0±0.2
Acidity, degree	2.2±0.2	2.2±0.2
Organoleptic evaluation, point	86.0	88.0

*Composed by the authors.

So, by adding 25 % grape pomace powder in the pasta the strength of dry product has increased by 35.7 % as compared to the control variant, the cooking time - by one minute, while the loss of dry matters has grown up by 4.8 %, pasta mass growing coefficiet has increased by 2.4 % and the humidity of the cooked pasta - by 0.9 %. Besides, by adding the grape pomace powder, the organoleptic evaluation indices of the pasta products have exceeded those of the control variant due to the shape retention of the products during the cooking process. The quality of pasta acquired through adding grape pomace powder complies with the standards of GOST 51865-2002 (GOST R 51865-2002 Macaroni products).

Conclusion

Upon the research results the following conclusions can be inferred:

• The chemical composition of the food powders produced from the dried pomace of various red grape varieties has been studied and their safety indices have been determined. Per a number of safety and microbiological indices it has been clearly stated that the food powder manufactured from grape pomace can serve as a useful additive increasing the nutritional value of the macaroni products.

• It has been proved that supplementation of 25 % grape pomace powder will enable to increase the content of dietary fiber in the finished product in about 45 times.

• The quality and physicochemical indices of the new macaroni products comply with the requirements of the current normative documents.

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ՊԱՐԲԵՐԱԿԱՆԸ ՆԵՐԱՌՎԱԾ Է ԴՈԿՏՈՐԱԿԱՆ ԵՎ ԹԵԿՆԱԾՈՒԱԿԱՆ ԱՏԵՆԱԽՈՍՈՒԹՅՈՒՆՆԵՐԻ ԱՐԴՅՈՒՆՔՆԵՐԻ ԵՎ ԴՐՈՒՅԹՆԵՐԻ ՀՐԱՊԱՐԱԿՄԱՆ ՀԱՄԱՐ ՀՀ ԿԳՄՍՆ ԲՈԿ-Ի ԿՈՂՄԻՑ ԸՆԴՈՒՆԵԼԻ ԳԻՏԱԿԱՆ ՀԱՆԴԵՍՆԵՐԻ ՑԱՆԿՈՒՄ:

ИЗДАНИЕ ВКЛЮЧЕНО В ПЕРЕЧЕНЬ ВЕДУЩИХ НАУЧНЫХ ЖУРНАЛОВ ВАК МНОКС РА, В КОТОРЫХ ДОЛЖНЫ БЫТЬ ОПУБЛИКОВАНЫ ОСНОВНЫЕ РЕЗУЛЬТАТЫ И ПОЛОЖЕНИЯ ДИССЕРТАЦИЙ НА СОИСКАНИЕ УЧЕНОЙ СТЕПЕНИ ДОКТОРА И КАНДИДАТА НАУК.

THE JOURNAL IS INVOLVED IN THE LIST OF SCIENTIFIC PERIODICALS RELEVANT FOR PUBLICATIONS OF THE RESULTS AND PROVISIONS OF DOCTORAL AND PHD THESES AND APPROVED BY THE HIGHER EDUCATION QUALIFICATION COMMITTEE OF THE RA MoESCS.

ՀՈԴՎԱԾՆԵՐԻ ԸՆԴՈՒՆՄԱՆ ԿԱՐԳԸ

1. Հոդվածներն ընդունվում են հայերեն, ռուսերեն և անգլերեն լեզուներով:
2. Հոդվածի առավելագույն ծավալը չպետք է գերազանցի 10 համակարգչային էջը (ներառյալ ամփոփագրերը):
3. Հեղինակների թիվը չպետք է գերազանցի չորսը:
4. Հեղինակների տվյալներում պետք է ներառվեն հեղինակ(ներ)ի անունը, ազգանունը, հայրանունը, գիտական աստիճանը, աշխատավայրը, էլ. հասցեն:
5. Հոդվածը ներկայացվում է տպագիր և էլեկտրոնային (WORD ձևաչափով) տարբերակներով:
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7. Գրականության հղումները կատարվում են տեքստում՝ փակագծում նշվում են հեղինակը և հրատարակման տարեթիվը:
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9. Յուրաքանչյուր լեզվով ներկայացված ամփոփագրի ծավալը չպետք է գերազանցի 600 նիշը (առանց բացատների):
10. Հայերեն և ռուսերեն հոդվածների վերնագրերը, հեղինակ(ներ)ի տվյալները և բանալի բառերը ներկայացվում են հայերեն, ռուսերեն և անգլերեն լեզուներով:
11. Գրականության ցանկը ներկայացվում է այբբենական կարգով:
12. Էլեկտրոնային հղումը որպես աղբյուր մեջբերելիս գրականության ցանկում նշվում է դիտման ամսաթիվը:

Հոդվածներին ներկայացվող տեխնիկական պահանջներն են. անգլերեն և ռուսերեն հոդվածների տառատեսակը՝ Times New Roman, հայերեն հոդվածներինը՝ GHEA Grapalat, տառաչափը՝ 12, միջտողային տարածությունը՝ 1.5, վերնագիրը՝ մեծատառերով, գծապատկերները՝ Word, Excel ծրագրերով, աղյուսակները՝ ուղղահայաց դիրքով (Portrait), բանաձևերը՝ Microsoft Equation 3.0 ձևաչափով:

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6. **The article should have the following structure:** title, 5 keywords, "Introduction", "Materials and Methods", "Results and Discussions", "Conclusion", "References".
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