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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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Национальный аграрный униветситет Армении

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Activities Aimed at Improving Road Traffic Safety at Night

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ABSTRACT

Nighttime traffic risks have been thoroughly analyzed in the current work indicating the activities to be implemented to reduce the number of night accidents. It is shown that the normative standards for the brightness of street lighting in Armenia are rather low as compared to other countries. The types of luminaires providing the street lighting and their layout have to be assessed. Some measures have been presented to improve the driver's field of vision, the defects of widely used luminaires and the consequent dangers have been clarified, as well as a safe road lighting scheme has been suggested.

Introduction

Traffic accidents typically occur in a variety of conflict situations that are well studied and do not need to be revised. Traffic accidents happening at night time pose a serious problem, since the mentioned conflict situations are associated with limited visibility, fatigue and even drowsiness of the drivers whose eyesight is getting impaired at the dusk and in the darkness. Usually, the night traffic makes only 15-20 % of the total daily traffic; however accidents occurring in conditions of such low traffic intensity are almost half of the average daily accidents. Besides, evening twilight is more dangerous, during which about 65 % of traffic accidents happen, while in the morning it makes up to 25 %. The statistical analysis of night accidents indicates that their consequences exceed those of daytime data by 30 %-40 % regarding both the injured people and deaths. So, driving at night time is more dangerous (about in 2.5-3.5 times) than during the day, and the probability of lethal outcome increases up to 10 times (https://mash-xxl.info/info/574543/). The percentage of night accidents in residential settlements is a bit lower than that of on the roads outside the settlements. Considering the night hours, the main conflict situations occur in vehicle-person collisions.

Materials and methods

The growth of traffic accidents at night time against the daytime is accounted not only for insufficient vision, but also for a number of objective factors: fatigue, visual problems, distorted perception of distance, colour changes in different subjects, optical illusions, etc. However, in all

cases, the main problem is insufficient field of vision in all directions of the night traffic. As we can see, extensive activities need to be implemented to reduce the number of night traffic accidents, which should include all field-related organizations and individuals. Artificial street lighting (both traffic lights and located street lights) can never be compared with the amount of light provided by the sun, which is about 10 000 lux, and the brightness is 8000 kD/m^2.

Different countries have different normative standards for night lighting of their roads, where the brightness varies in the range of 1.6 - 4.2 kD/m^2; moreover, the brightness can vary from minimum to maximum 1:1.3 in dry weather and up to 1: 1.6 in rainy weather. It should be mentioned that the normative indicators of night lighting are stated by the Ministry of Urban Development of the RA, upon the Decree № 82, 06.08.1996 (Construction Code of the RA, Decree № 82, 06.08.1996).

The study of the mentioned document shows that the defined indicators revise the normative indicators that have been operating in the USSR for years and are still operating in Russian Federation. For comparison, we can mention that in Armenia, the norm for brightness is 1.6 kD/m^2, in many European countries it ranges from 2 to 2.6 kW/m^2, while in the USA it amounts to 4.2 kW/m^2.

It's not accidental that in Armenia the dominant part of traffic accidents are night accidents, and as a matter of fact, most of all have tragic consequences because on the one hand, the norms are weak, and on the other hand, those norms are not even ensured. Along with street lighting the road cover type, markings made on them, the types of road signs and installation methods, the dye-stuff used for marking should be taken into account. The light fittings used for the street lighting, the ways of their installation, the use of light effects in the roadside areas and on the advertising boards are worth special evaluation. Application of LED lights and the presence of timers significantly facilitate the driver's work; anyhow new problems appear in the dark hours of the day.

The brightness of LED lights considerably exceeds the brightness of the lights used before. In the presented diagram (Figure 1), the driver has the signals of (a) and (b) traffic lights in his field of vision in the daylight hours, so he can choose an optimal mode of movement only in the daylight hours, since at this time the driver clearly identifies (a) and (b) traffic lights and the distance between them.

The situation is rather different at night time, especially during the rain. In this case, the driver approaching the (a) traffic light can see both (a) and (b) traffic lights in the dark, but very often he can't figure out which on-off light signal he is concerned with until he is very near to the (a) traffic light. Orientation at the last moment and drastic actions can cause emergency situations and also traffic accidents. A number of such driving sites can be mentioned in Yerevan, e.g. Tbilisi highway. However, we can eliminate this confusing situation due to some technical changes. Let's consider the diagram of traffic light change with horizontal layout.

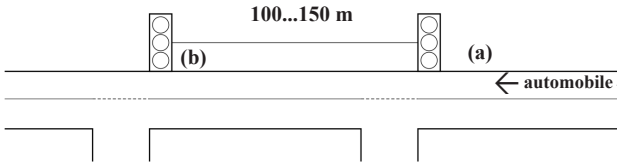

Figure 1. Traffic lightsplaced at a distance of 100 -150m (*composed by the authors*).

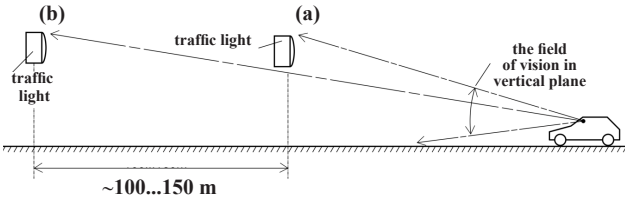

Figure 2. Traffic lights appeared in the driver's field of vision in vertical plane (*composed by the authors*).

Figure 2 shows that both (a) and (b) traffic lights are located in the driver's field of vision. Let's consider the proposed changing diagram for removing the (b) traffic light from the driver's field of vision (Figure 3).

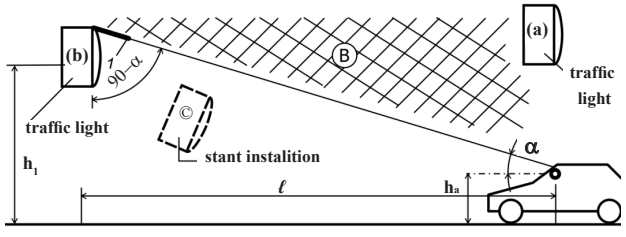

Figure 3. The diagram of removing the (b) traffic light from the driver's field of vision (*composed by the authors*).

LED lamps usually have a fairly narrow angular range of light radiation. Therefore, it'll be better to place a cover on the traffic light bent at a certain angle, moreover the bending angle of the cover depends on the dimensions of the environment, which will intervene the light dispersion over the darkened sector (B). It's also possible to use the (c) variant, where only the traffic light bents at a certain angle providing better visual opportunity within the (a) – (b) range. The size of *a* angle can be calculated for each point in the following way:

$$tga = \frac{h_l - h_a}{l},$$

where h_l is the height of the traffic light from the road, h_a is the average height of the driver's eye from the road, l is the distance projection between the driver's eye and the traffic light, where the traffic light should be seen.

Road lighting significantly changes depending on what cover it has. It is a fact that asphalt roads are poorly lightened, especially when it rains. The appearance of the thinnest snow layer on the road is enough to create an ideal lighting. From this point of view, concrete roads are in better position. So, it becomes obvious that it's desirable to have such a cover on the road which will provide the needed light reflection. White line marks are very noticeable on the asphalt roads and yellow line marks - on the concrete roads. It should be always noted that if the driver doesn't clearly distinguish the road from the roadside due to the road lighting, then it'll always bring to dangerous consequences.

Results and discussions

Recently, the most widely used modern lighting devices have significantly affected the safety of night traffic (https://works.doklad.ru/view/5FkryDSLQTI.html). When we just walk through the streets of any settlement in the evening, we can see road sections illuminated with bright lights. Besides, many luminaires are placed in such a way that the powerful ray of the light is directed straight to the moving car (in gas stations, cafes and other complexes). Of course, the driver's eye gives a corresponding biological reaction: the eye pupil gets narrow, as a result of which the driver hardly makes out the road situation. There can be even situations when the monitor placed on the road emits such a bright light over its surface which immediately blinds the driver (for example, at the top of "Lambada" crossroad).

Such problems can be solved by eliminating the shortcomings enhanced as a result of regular professional monitoring. The studies have shown that luminaires have dangerous disadvantages. The fact is that widely used luminaires (Figure 5) are very suitable for night lighting of the yards and recreation areas, but not for streets and roads.

Columns equipped with such lamps, placed along the road at l distance from each other, provide the road with very bright lighting points in case when brightness of the road is ten times lower (Figure 4).

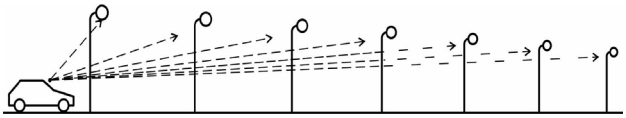

Figure 4. The effect of incorrectly selected road lights on the driver's eyes (*composed by the authors*).

Partial blindness caused by such luminaires is very noticeable during the rain and completely disappears during the snowfall. The mentioned unfavorable situation is connected with the fact that the lamp (Figure 5) emits the light with an aperture of about 160-170^0, in case when we need to have what is depicted in Figure 6 to illuminate the street.

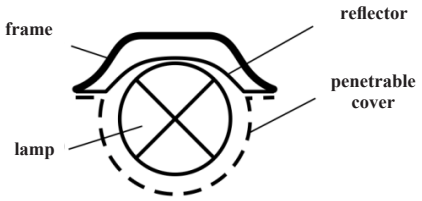

Figure 5. Exterior lighting lamps (*composed by the authors*).

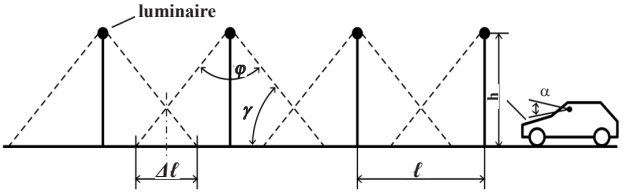

Figure 6. Proper road lighting diagram (*composed by the authors*).

As we can see from the diagram, the luminaires don't appear in the driver's field of vision; therefore his eyes react only to the road surface lighting. The mentioned was also proved through an experimental method. As shown in Figure 6, the car is parked on the right side of the illuminated street with the nearby lights on. Visibility of the sidewalk was assessed when there was a traffic flow in the opposite lane (lights on) and when it was absent.

From the driver's seat, per the eye position, photo was taken for both cases. Then the driver compared the image of the photo with the image he perceived, and as a result, it was found out that there is a significant difference. Naturally, the difference is due to the physiological properties of the eye associated with the accommodation of the lens of the eye.

Thus, for correct and safe lighting along the longitudinal direction of the road, it's necessary that the lighting emits only at a certain φ angle, the magnitude of which can be calculated through the following formula: $\varphi = 2\,(90\text{-}\gamma)$, where:

$$tg\gamma = h / \left(\frac{l}{2} + \frac{\Delta l}{2} \right),$$

where Δl is the sector, which is illuminated by two adjacent luminaires at the same time, l is the distance between the two adjacent luminaires, h is the distance between the luminaire and road cover, γ is the angle formed by the light emitted from the road cover and luminaire. So, we can accept that:

$$\Delta l = \frac{l}{3},$$

therefore:

$$tg\gamma = \frac{h}{\left(\frac{l}{2} + \frac{\Delta l}{6} \right)} = h / \frac{2}{3} l.$$

Conclusion

Thus, the correct choice of the road surface type and its line marks, the road signs and their installation places, the types of luminaires and the ways of their installation, as well as the accurate use of billboards and provision of proper night lighting in the roads will enable to significantly increase the safety of night traffic.The development and application of technical measures that could block the car driving (especially at night) for tired (drowsy) drivers will also contribute to the safety increase. It is also recommended that novice drivers with less than a year of experience (or those having 5000 km run) shouldn't drive at night.

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Developing Ways to Improve Traffic Management on Gayi Avenue

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ABSTRACT

The article considers the ways of road traffic improvement through the coordinated management system on Gayi Avenue. The system has been designed to reduce traffic delays, which could entail to positive results, suh as optimal speed, increased safety, reduced environmental pollution, traffic jam reduction, etc. As a result of the current research it has become obvious that there is an urgent need to implement an automated traffic control system in order to organize safe traffic in the main streets of Yerevan.

Introduction

Traffic management is a set of organizational and engineering measures that are implemented in the existing road network, ensuring the safety of vehicles, pedestrians, as well as the necessary speed. As already mentioned, nowadays it is necessary to implement an automated traffic control system (ATCS) in the main streets of Yerevan, which includes coordinated traffic management (Khilazhev and Sokolovsky, 2003). Consistent operation of a number of traffic lights is called coordinated system, which is aimed at the reduction of traffic delays. The principle of coordinated managemet consists of the process where the green signal at the next crossroad is switched on with a certain shift as compared to the previous crossroad, the duration of which depends on the passing time of vehicles across these crossroads. Thus, vehicles seem to move according to a schedule, approaching the next intersection at the moment when the green signal is turned on in the mentioned direction. After implementation of the system, the number of road accidents will be reduced by 10 %-15 %, and the traffic delays - by 15 %-20 % (Kremenets, 2005).

Materials and methods

Gayi avenue is one of the main streets of Yerevan. It has an overloaded traffic and is provided with intensive transport means which cause traffic delays, congestions, road traffic accidents, since the current methods of traffic organization fail to provide the needed results. The considered avenue is of 2300 m length and intersects the streets of D. Malyan, Moldovakan, Totovents, Safaryan, Hovhannisyan and Gyulikevkhyan. There are three or four lanes towards each traffic direction in Gayi avenue. The maximum distance between successive intersections is 532 meters. Such conditions enable to introduce one of the elements (coordinated management) from the automated management system in the traffic organization process.

Table 1. Traffic speed of vehicles in the highway street*

Speed of vehicles per ranges (km / h)	Average speed value within the ranges (km / h)	The number of vehicles	Distribution per frequency %	Accumulation of frequency in ascending order %
20-30	25	8	4	4
30-40	35	24	12	16
40-50	45	88	44	60
50-60	55	64	32	92
60-70	65	12	6	98
70-80	75	4	2	100
Total		200	100	

Table 2. The highway sizes*

Crossroads	Crossroad width (m)	District length (m)	Roadway width (m)	Number of traffic zones in one coordinated direction
1. Gayi av. – D. Malyan st.	28	0	16.3	3 (4)
2. Gayi av. – Moldovakan st.	70	495	21.20	3 (4)
3. Gayi av. – Totovents st.	36	230	23.90	3 (4)
4. Gayi av. – Safaryan st.	35	290	29.30	3 (4)
5. Gayi av. – Hovhannisyan st.	34	420	23.60	3 (4)
6. Gayi av. – Gyulikevkhyan st.	81	532	26.85	3

Table 3. The maximum intensity of traffic flows per directions on working days*

Directions / Number	I			II			III			IV		
	straight	right	left	straight	right	left	straight	right	left	straight	right	left
1	-	-	-	-	320	-	2405	121	-	602	-	329
2	1996	132	91	86	404	189	2014	101	118	24	59	304
3	1790	118	83	117	167	144	2094	132	243	102	58	192
4	1610	431	-	-	143	304	1918	178	244	-	203	360
5	1468	30	76	104	281	25	1737	158	31	46	55	137
6	1410	43	148	34	149	45	1664	110	161	45	133	72

*Composed by the author.

This system is based on three terms, two of which are already provided: more than two traffic lanes and less than 800 m distance should be ensured between the adjacent crossroads; the third term which is related to the availability of the similar adjustment cycle in the crossroads will be provided through the further calculations.

The baseline data needed for the contribution of coordinated management system to the Gayi avenue are introduced in Tables 1, 2, 3 and in Figure 1 (Rusevskiy, 2015).

Based on the data of Table 1, the histogram of vehicle speeds and a distribution curve per ranges are designed (Figure 2). The accumulation curve is designed in ascending order by adding the frequency percents in the 5th column of Table 1, which enables to determine the estimated speed of coordinated control with reliability per any percent (Figure 3).

The horizontal axis shows the speed of cars, while the vertical axis shows the frequency accumulation in ascending order. Typical points for the accumulation curve are the levels corresponding to 15 % (minimum allowable speed), 50 % (average speed value of the vehicles) and 85 % (maximum allowable speed) reliability. The speed value obtained via the mentioned method is surely to be rounded to the nearest ten unit. Thus, 50 km/h is selected as the calculated speed for coordinated control.

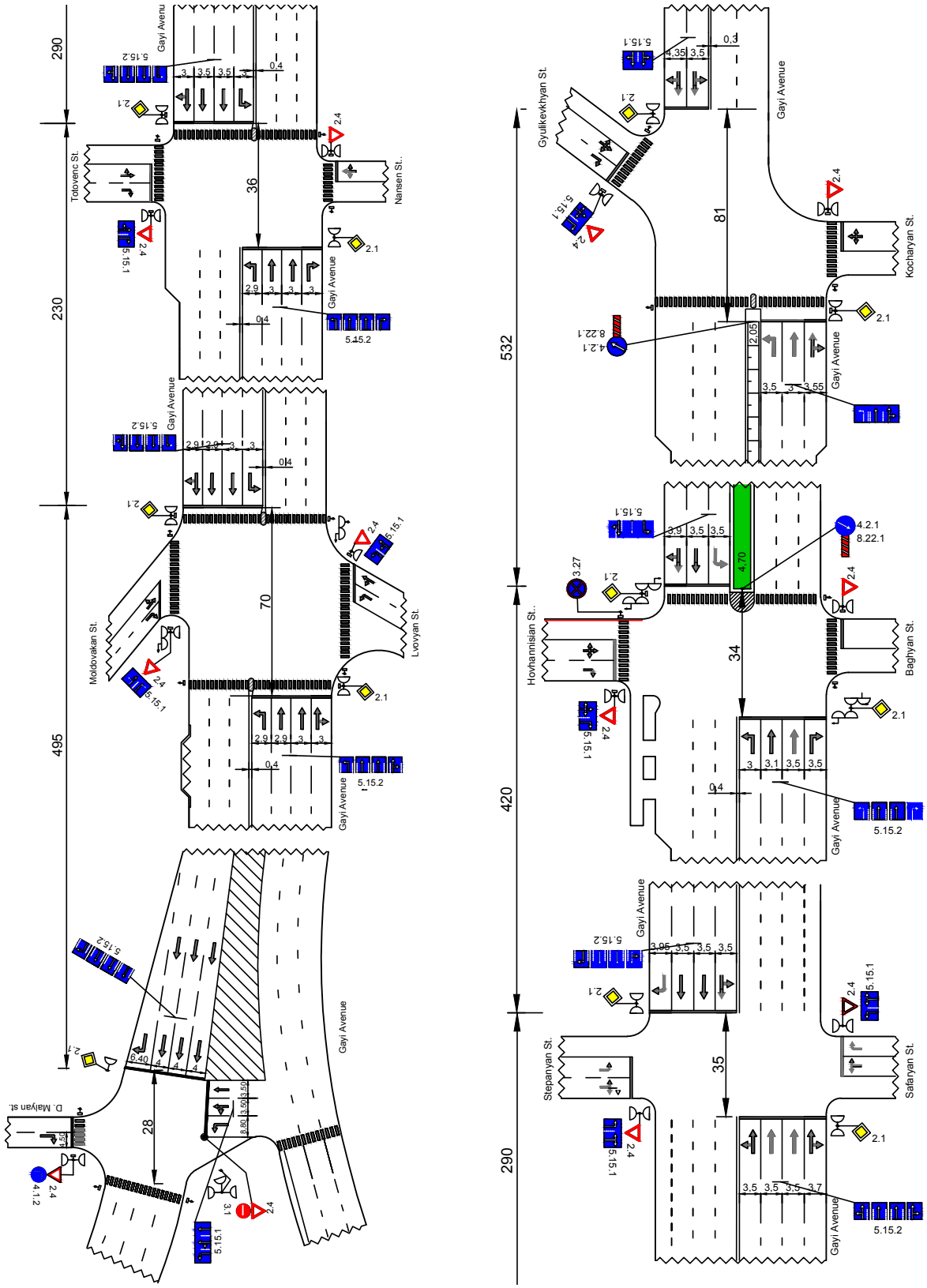

Figure 1. Diagram of Gayi Avenue (*composed by the author based on GOST 23457-86, 2013*).

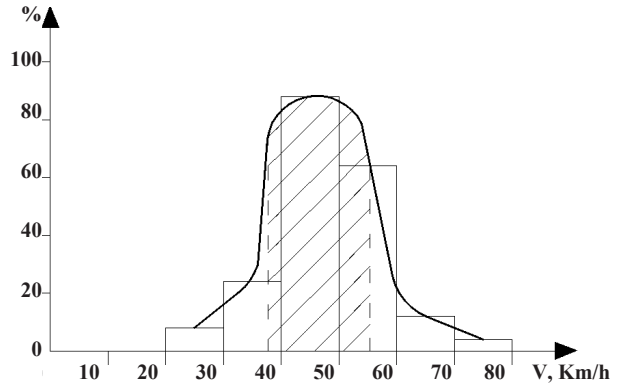

Figure 2. Vehicle speed histogram (*composed by the author*).

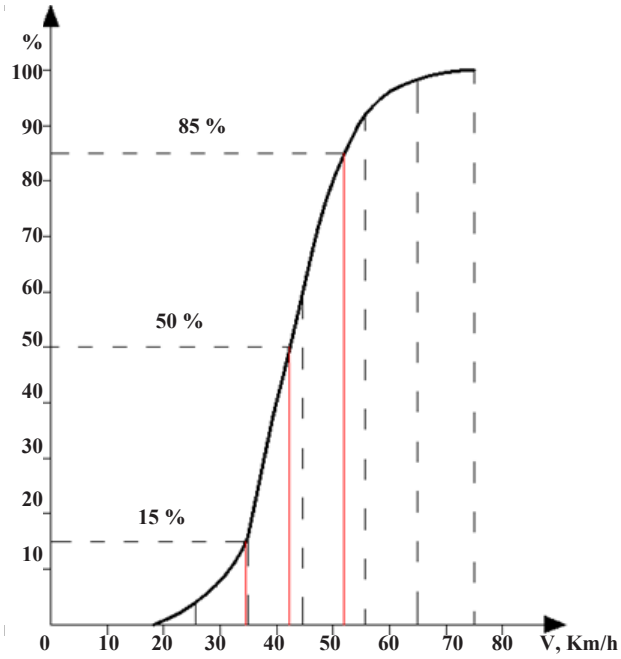

Figure 3. Vehicle accumulation curve (*composed by the author*).

Results and discussions

Now let's consider the intersections of Gayi avenue individually.

1. Gayi av. - D. Malyan st. crossroad: two-stage traffic organization is implemented at the mentioned crossroad. According to the data available in Table 4, the intensity of the busiest zone in the first stage will be (Rushevskiy, 2015):

$$N_1 = (N_{straight} + N_{right} + N_{left})/K_{mz} = (2405+121+0)/3.5 = 721 \text{ m/h},$$

where $N_{straight}$, N_{right} and N_{left} are the maximum intensities of straight , right and left traffic flows respectively, K_{mz} – multi-lane road coefficient: in case of the 1st road zone it is equal to 1, for the 2nd road zone - 1.9, for the 3d and 4th zones - 2.7 and 3.5 respectively. The intensity of the busiest zone (N_2) in the second stage will be:

$$N_2 = (N_{straight} + N_{right} + N_{left})/K_{mz.} = (602+0+329)/2.7 = 345 \text{ m/h}.$$

According to the approximate formula, the duration of the rigid adjustment cycle for traffic lights at the intersection of Gayi Avenue - D. Malyan street will be:

$$T_c = (N_1 + N_2)/14 = (721 + 345)/14 = 76 \text{ s}.$$

2. Gayi av.- Moldovakan st. crossroad: directional traffic organization is implemented at the mentioned intersection. The intensity of the busiest zone of the first stage (N_1) will be:

$$N_1 = (2014+ 101+ 118)/3.5 = 638 \text{ m/h}.$$

The intensity of the busiest zone of the second stage (N_2) will be:

$$N_2 = (86+ 404+ 189)/1.9 = 357 \text{ m/h}.$$

The duration of the rigid adjustment cycle for the traffic light in the given intersection will be:

$$T_c = (638 + 357)/14 = 71 \text{ s}.$$

3. Gayi av.- Totovents st. crossroad: the intensity of the busiest zone of the first stage (N_1) will be:

$$N_1 = (2094+ 132+ 243)/3.5 = 705 \text{ m/h}.$$

The busiest zone of the second stage (N2) will be equal to:

$$N_2 = (117+ 167+ 144)/1.9 = 225 \text{ m/h}.$$

The duration of the rigid traffic light adjustment cycle will be:

$$T_c = (705+ 225)/14 = 66 \text{ s}.$$

4. *Gayi av.– Safaryan st. crossroad*: for this intersection the traffic intensity of the busiest zone in the first stage (N_1) will be:

$$N_1 = (1918+ 178+ 244)/3.5 = 668 \text{ m/h}.$$

For the second stage (N_2) it will be equal to:

$$N_2 = (0+ 203+ 360)/1.9 = 296 \text{ m/h.}$$

The duration of the rigid traffic light adjustment cycle for the mentioned intersection will be:

$$T_c = (668+ 296)/14 = 68 \text{ s.}$$

5. Gayi av. – Hovhannisyan st. crossroad: the intensity of the busiest zone for the first stage (N_1) will be:

$$N_1 = (1737+ 158+ 31)/3.5 = 550 \text{ m/h.}$$

The intensity of the busiest zone in the second stage (N_2) will be equal to:

$$N_2 = (104+ 281+ 25)/1.9 = 215 \text{ m/h.}$$

The duration of the rigid traffic light adjustment cycle will be:

$$T_c = (550+ 215)/14 = 55 \text{ s.}$$

6. Gayi av. – Gyulikevkhyan st. crossroad: the intensity of the busiest zone of the first stage (N_1) will be:

$$N_1 = (1664+ 110+ 161)/2.7 = 716 \text{ m/h.}$$

The intensity of the busiest zone for the second stage (N_2) will be equal to:

$$N_2 = (45+ 133+ 72)/1.9 = 131 \text{ m/h.}$$

The duration of the rigid traffic light adjustment cycle will be:

$$T_c = (716+ 131)/14 = 61 \text{ s.}$$

After calculating the cycles, the duration of the intersection adjustment cycle that has the highest value is selected as the estimated one. The intersection of Gayi av.-D. Malyan st. ($T_c = 76$ s) is considered to be the "nodal/main crossroad". The adjustment cycle duration of the "nodal crossroad" is extended to all intersections, providing the second term for the introduction of coordinated control system (Klinkovstein, 2001). Then the duration of the green signal at each intersection is calculated using the following formula:

$$t_{gr} = t_0 – q + (N*T_c / 3600) * \text{q,}$$

where t_0 is the driver's reaction time (for calculations $t_0 = 2$ seconds), q is the minimum safe time span between vehicles (for mixed traffic $q = 3$ seconds), N is the intensity of the heaviest zone, T_c is the value of the "nodal crossroad" cycle. After calculating the main strokes (timing period), it is necessary to implement checking:

$$T_{c.} - t_{gr1} – t_{int/s} – t_{gr2} – t_{int/s} = 0 \text{ sec.}$$

If this condition is not met, the extended period is added to the main strokes in percent. The coordinated direction is provided with 50 %-70 %, in case of three stage adjustment - with 50 %, and the other two stages - with 2 5 %. The duration of intermediate stroke at the intersection of Gayi Avenue is 4 seconds.

• At the crossroad of Gayi av.- D. Malyan st. the duration of the green signal will be:

$$t_{gr1} = t_0 – q + (N*Tg / 3600) * q =$$
$$= 2 – 3 + (721 * 76 / 3600) * 3 = 47 \text{ sec.}$$

$$t_{gr2} = 2 – 3 + (345 * 76 / 3600) * 3 = 21 \text{ sec.}$$

$$76- 47- 4- 21- 4 = 0 \text{ sec.}$$

• At the crossroad of Gayi av.- Moldovakan st. the duration of the green signal will be:

$$t_{gr1} = t_0 – q + (N*Tg / 3600) * q =$$
$$= 2 – 3 + (638* 76 / 3600) * 3 = 39 \text{ sec.}$$

$$t_{gr2} = 2 – 3 + (357 * 76 / 3600) * 3 = 22 \text{ sec.}$$

$$76- 39- 4- 22- 4 = 7 \text{ sec.}$$

This condition is not met:

$$t_{gr1} + 7*70 \% = 39+5 = 44 \text{ sec.}$$

$$t_{gr2} + 7*30 \% = 22+2 = 24 \text{ sec.}$$

$$76- 44- 4- 24- 4 = 0 \text{ sec.}$$

• At the crossroad of Gayi av.- Totovents st. the duration of the green signal will be:

$$t_{gr1} = t_0 – q + (N*Tg / 3600) * q =$$
$$= 2 – 3 + (705* 76 / 3600) * 3 = 44 \text{ sec.}$$

$$t_{gr2} = 2 – 3 + (225 * 76 / 3600) * 3 = 13 \text{ sec.}$$

$$76- 44- 4- 13- 4 = 11 \text{ sec.}$$

The condition is not met:

$$t_{gr1} + 11*70 \% = 44+8 = 52 \text{ sec.}$$

t_{gr2} + 11*30 %= 13+3 = 16 sec.

76-52-4-16-4 = 0 sec.

• At the crossroad of Gayi av.– Safaryan st. the duration of the green signal will be:

$t_{gr1} = t_0 – q + (N*Tg / 3600) * q =$
$= 2 – 3 + (668* 76 / 3600) * 3 = 41$ sec.

$t_{gr2} = 2 – 3 + (296 * 76 / 3600) * 3 = 18$ sec.

76- 41- 4- 18- 4 = 9 sec.

The condition is not met:

t_{gr1} + 9*70 % = 41+6 =47 sec.

t_{gr2} + 9*30 %= 18+3 = 21 sec.

76-47-4-21-4 = 0 sec.

• At the crossroad of Gayi av. – Hovhannisyan st. the duration of the green signal will be:

$t_{gr1} = t_0 – q + (N*Tg / 3600) * q =$
$=2 – 3 + (550* 76 / 3600) * 3 = 34$ sec.

$t_{gr2} = 2 – 3 + (215 * 76 / 3600) * 3 = 13$ sec.

76- 34- 4- 13- 4 = 21 sec.

The condition is not met:

t_{gr1} + 21*70 % = 34+15 = 49 sec.

t_{gr2} + 21*30 %= 13+6 = 19 sec.

76-49-4-19-4 = 0 sec.

• At the crossroad of Gayi av. – Gyulikevkhyan st. the duration of the green signal will be:

$t_{gr1} = t_0 – q + (N*Tg / 3600) * q =$
$= 2 – 3 + (716* 76 / 3600) * 3 = 44$ sec.

$t_{gr2} = 2 – 3 + (131 * 76 / 3600) * 3 = 7$ sec.

76- 44- 4- 7- 4 = 17 sec.

The condition is not met:

t_{gr1} + 17*70 % = 44+12 =56 sec.

t_{gr2} + 17*30 %= 7+5 = 12 sec.

76-56-4-12-4 = 0 sec.

The coordinated management schedule is built in the following order (Novikov, 2009):

- Drawing the plan of the coordinated road keeping the vertical scale to the left of the vertical axis in the path-time coordinate system,
- Writing the design of adjustment cycle in front of each intersection,
- Drawing corresponding lines parallel to the horizontal axis over the borderline of each intersection,
- Setting up the adjustment cycle stages from left to right per scales along the borderlines drawn for the nodal crossroads,
- Drawing the time span (t_s) through the oblique lines (φ) from the start of the green signal towards the horizontal axis.

The tangent of the angle in oblique lines drawn towards the horizontal axis is proportional to the traffic speed:

$tg_\varphi = V_{est.} * M_h /3.6 * M_v = 50 * 0.5 /3.6 * 5.6 = 1.24,$

$\varphi = arctg\ 1.24= 51°,$

where $V_{est.}$ is the estimated traffic speed, M_h is the horizontal scale, M_v is the vertical scale.

The width of the time span is within the following limits:

$t_{gr} \geq t_s \geq 0.65\ t_{gr},$

where t_s is the maximum duration of the green signal at the nodal crossroad:

$t_s = 0.65 * 47 = 30.5$ sec.

In order to ensure unobstructed passage of vehicles in the direction of the coordinated road, the green signals of the traffic lights must have some shifts:

$t_{sh.} = 3.6 * L / V_{est.},$

where $V_{est.}$ is the estimated traffic speed, L is the length of the calculated space. Shifts are calculated from the main crossroads: thus, from the crossroad of Gayi av.- D. Malyan to that of Gayi av.- Moldovakan st.:

$t_{sh} = 3.6 * 495 / 50 = 36$ sec.

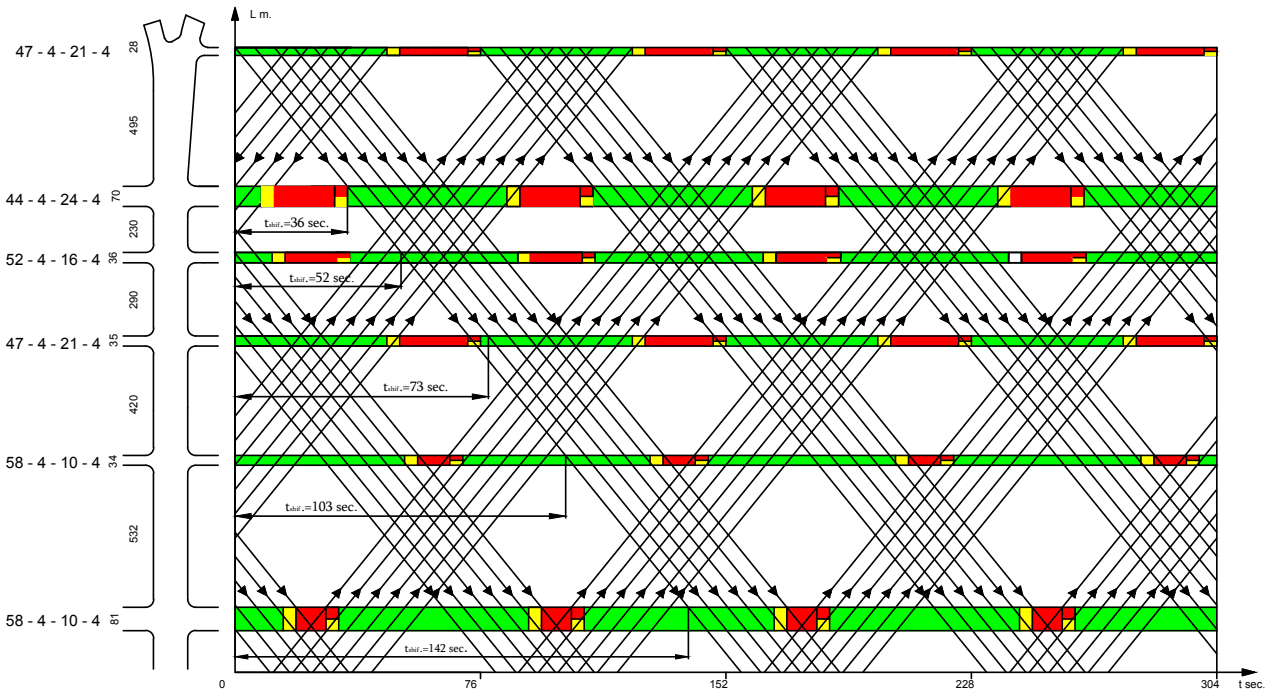

Figure 4. Coordinated management schedule (*composed by the author*).

From the crossroad of Gayi av.- D. Malyan to that of Gayi av.- Totovents st.:

$$t_{sh.} = 3.6 * 720 / 50 = 52 \text{ sec.}$$

From the crossroad of Gayi av.- D. Malyan to the Gai av.– Safaryan st. crossroad:

$$t_{sh.} = 3.6 * 1015 / 50 = 73 \text{ sec.}$$

From the crossroad of Gayi av.- D. Malyan to the Gayi av. – Hovhannisyan st. crossroad:

$$t_{sh.} = 3.6 * 1435 / 50 = 103 \text{ sec.}$$

From the crossroad of Gayi av.- D. Malyan to the Gayi av. – Gyulikevkhyan st. crossroad:

$$t_{sh.} = 3.6 * 1967 / 50 = 142 \text{ sec.}$$

The coordinated management schedule is presented in Figure 4 (Graphic-analytical method, 2013).

After designing the diagram, it becomes clear that the time span partially falls on the red signal at the crossroads of Gayi av. – Gyulikevkhyan st. and Gayi av. – Hovhannisyan st. There are 3 options for eliminating the mentioned problem: 1- reducing the time span, 2 - increasing the green signal duration and 3-reducing inclination in the time span angle. Since the time span has been calculated as equal to 0.65 t_{gr}, the problem can be solved by increasing the duration of the green signal in the conflict direction. After making the relevant changes, the structure of adjustment cycle at the mentioned intersections will be 58-4-10-4, 58-4-10-4 respectively.

Conclusion

Taking into account the abovementioned interpretations it can be stated that the introduction of the discussed coordinated management system in Gayi avenue will promote the increase of traffic safety, reduction of vehicle delays and traffic congestions, as well as the number of accidents, thereby somewhat improving traffic management. So, the approach of the transport means to the next intersection should occur at the moment, when the green signal is turned on in that specific direction.

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Estimation of Environmental Efficiency for the Liquefied Gas Use as a Motor Fuel in the Internal Combustion Engine of Motor Vehicles

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ABSTRACT

Currently, the use of various types of alternative motor fuels, such as natural gas, methane (in liquefied or compressed form) and liquefied petroleum gas (LPG), has become more common in the world. In addition, various studies are carried out on the application of biological, synthetic fuels, dimethyl ether, etc. The widespread use of each of these fuels in internal combustion engines has both advantages and disadvantages, measured not only in terms of economic attractiveness, but also in terms of environmental safety. This article provides a method for estimating the environmental efficiency of liquefied gas as a motor fuel in vehicles.

Introduction

It is known that the operation of an internal combustion engine is accompanied by exhaust gas toxicity, in which about 1000 chemical compounds are found (Zvonov, 1981). The most dangerous ones, having a certain specific weight, are the carbon oxides (CO – 10 %), nitrogen oxides (NOx – 0.8 %), unburned hydrocarbons (UHCs – 3 %), aldehydes (0.2 %) and carbon black (Simonyan, Asatryan, 2013).

Taking into account the fact that the application of gas fuel in the car engines considerably reduces the amount of toxic compounds released into the atmosphere (Simonyan, 2011), the activities aimed at the solution of the mentioned problem become urgent due to the time demand.

Materials and methods

The chemical compounds discussed in the previous section have different effects on human organisms, since they have various toxicity degree and are characterized by different hazard levels. Besides, the mentioned compounds differ from each other by their quantity and volume in the exhaust gas of the car engine; that is why to provide clear distinction which compound is more dangerous for a specific car model is rather difficult (Korotkov, Filippov, 2008).

The total level of various toxic compounds in the exhaust gases is viewed as the hazard level in the car exhaust gases (Korotkov, Filippov, 2008).

From the environmental standpoint the gas fuels are serious competitors with the traditional oil fuels. The latter

are based on the ratio of H/C (Abed Alib, et al., 2010).

Based on the aforementioned facts and the circumstance that the liquefied petroleum gas vehicles, particularly the light cars, have become widely used in Europe and CIS countries, which are mostly for personal use and passenger transportation companies (TAXI), it becomes necessary to study and assess the toxicity rate of the exhaust gas from the car engine depending on the car mileage (run).

Results and discussions

For our experiments new MERCEDES car model with a run of up to 5000 km and with E-class universal car body working with liquefied petroleum gas with 3.2 L swept-volume capacity has been selected, which is most applicable but not limited to passenger motor vehicles.

The estimation of both mass and volumetric toxicity of the exhaust gases from the MERCEDES cars has been conducted by means of GAS analyzer, the technical description of which (parameters) is introduced in Table 1, while the general view and operational state are presented in Figure 1 (a, b).

Table 1. The technical description of Gas analyzer*

Chemical composition	Range	Resolution
HC	0 - 2000 ppm	1 ppm
CO	0 - 15 %	0.001 vol%
CO_2	0 - 20 %	0.01 vol%
O_2	0 - 25 %	0.01 vol%
NOx	0 - 5000 ppm	1 ppm
Working conditions		
Temperature	0-50 degree C	
Humidity	Up to 95 % non-condensing	
Altitude	- 300 to 2.500 m	
Vibration	1.5 G sinusoidal 5 - 1000 Hz	
Shock	1.22 m drop to concrete floor (gas analyzer)	
Response Time	0 - 90 % <= 8 seconds for NDIR measurements	
Pocket PC Power	5 VDC 2 Amps max	
Operating System	Windows Mobile/CE version 3.0 or later	

*Composed by the author.

a)

b)

Figure 1. Estimation of the toxicity for the exhaust gases from the engine of MERCEDES-benz.

The experiments have been implemented in consistent with the standards of GOST 31967-2012, on the roads of the 1st category, at the constant vehicle speed, according to which after 5000-10000 km mileage run, at each 10000 km, the toxicity of the exhaust gases was determined, the average data of which are summed up in Table 2 and in Figure 2 (a, b, c).

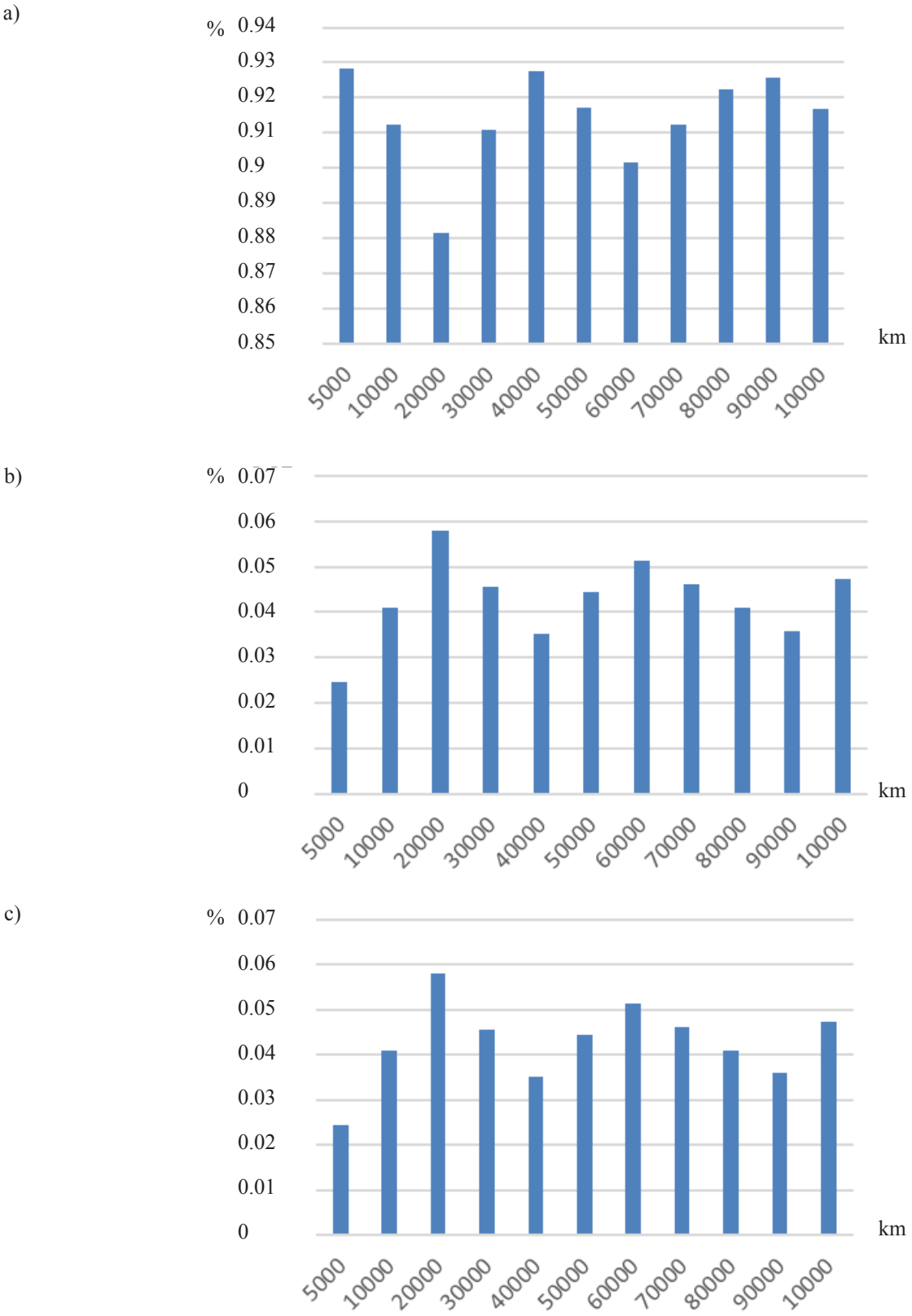

Figure 1. The amount of toxic compound emissions from MERCEDES-benz depending on its run.
a) The amount of CO b)The amount of UHC c) The amount of NOx (*composed by the author*).

Table 2. The amount of toxic compounds in the exhaust gases from the car model of MERCEDES-benz*

Run/Mileage, km	CO		HC		NOx		Σ	
	g/km	%	g/km	%	g/km	%	g/km	%
5000	4.54	0.928425	0.23	0.047035	0.12	0.02454	4.89	100
10000	4.68	0.912281	0.24	0.046784	0.21	0.040936	5.13	100
20000	3.95	0.881696	0.27	0.060268	0.26	0.058036	4.48	100
30000	4.6	0.910891	0.22	0.043564	0.23	0.045545	5.05	100
40000	4.75	0.927734	0.19	0.037109	0.18	0.035156	5.12	100
50000	4.55	0.917339	0.19	0.038306	0.22	0.044355	4.96	100
60000	4.22	0.901709	0.22	0.047009	0.24	0.051282	4.68	100
70000	3.95	0.91224	0.18	0.04157	0.2	0.046189	4.33	100
80000	4.05	0.922551	0.16	0.036446	0.18	0.041002	4.39	100
90000	4.12	0.925843	0.17	0.038202	0.16	0.035955	4.45	100
100000	4.07	0.916667	0.16	0.036036	0.21	0.047297	4.44	100

*Composed by the author.

The results of the research (Table 2), which have been carried out at the altitude of 80 m above sea level will enable to accomplish the following tasks:

1. to estimate the amounts of toxic emissions from the light motor vehicles (by the example of MERCEDES-benz), when working with liquefied petroleum gas,
2. to deduct a dependence characterizing the changes in toxic emission amounts from the engine due to the rate of vehicle run,
3. to compare and classify the toxic compounds in the exhaust gases,
4. to measure the amounts of toxic emissions and to compare them with the current standard values accepted in the Republic of Armenia,
5. to establish a comparative parametric database in case of obtaining similar results from new research conducted in the RA, which will be characteristic both to mountainous conditions (e.g. RA) and the areas close to sea level,
6. to compare the exhaust toxic gases from the engines of light motor vehicles working with compressed natural gas with equivalent compounds.

So, the data of Table 2 and Figure 2 indicate that the carbon oxide (CO) makes the overwhelming part of toxic emissions fluctuating within the range of 91 %-92 %, the unburned hydrocarbons (UHCs) are involved within the range of 3.6-6.0 in the domain of toxic emissions, and the share of nitrogen oxide(NOx) in the mentioned domain makes 2.4 %-5.8 %.

Conclusion

Upon the results of conducted research the following conclusions can be drawn:

Localization of the results of such scientific experiments or implementation of another research with the same content is urgent due to the abrupt increase in the number of motor vehicles running on liquefied petroleum gas in Armenia for recent years.

The carbon oxide (CO) is considered to be the most hazardous compound, which exceeds 90 % of the total amount of toxic compounds in the exhaust gases from the engine.

The ratio of nitrogen oxide (NOx) doesn't exceed 6 % of the total due to which we can view it as insignificant but not ignored.

The ratio of unburned hydrocarbons (UHCs) doesn't exceed 6 % either.

Parallel to the increase of the motor car run a maintaining tendency for the average values of toxic compounds in the exhaust gases of the engine is recorded.

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Issues of Swine Breeding Development and the Main Solution Ways in the Republic of Armenia

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ABSTRACT

Within the frame of the current scientific article the production and economic indicators of the swine breeding branch in the economy of Armenia have been analyzed. The strategic role and significance of the branch development have been justified putting stress on the increase of self-sufficiecy level of the pork production in the republic. In the mentioned context the disclosure of the issues existing in the swine breeding branch of the RA has been considered as a priority, the solution of which will enable to increase the self-sufficiency level of pork in the country ensuring growth in the consumption sizes of the local pork production, as well as increase in the share of the local production within the overall structure of pork consumption.

Introduction

The agricultural production is one of the main sectors of economic development, which provides the population with food product and supplies the light and food industry with raw material. Moreover, the agricultural sector is of vital importance for the increase of economic independence and, therefore, for the provision of national security of any country.

Provision of safety in the agri-food system is a permanent priority to ensure the national security of any country, particularly in the current conditions, when related to the pandemic of coronavirus, the urgency of food provision issue has increased and all countries try to create a great amount of food product supplies to possibly provide their own population with basic foodstuffs for a long-term perspective. To this end the countries seek to pursue a policy which would entail to the increase in the level of self-sufficiency and safety provision in agri-food system.

Materials and methods

General and holistic analysis of the swine breeding branch has been conducted based on our studies and statistical data published in the collections of the National Statistical Committee of the RA. Throughout our investigations the main field-related problems requiring urgent solutions have been enhanced, which will enable to further improve and develop the current situation of the swine breeding branch in Armenia. In the framework of conducted studies scientific abstraction and research methods, as well as computational, graphical, comparative and statistical methods have been applied which promoted more descriptive and comprehensive consideration and presentation of the field issues and the steps for their disclosure and solution.

Results and discussions

Livestock is one of the main branches of the RA agricultural sector, which has a considerable role in the provision of livestock product to the population of the country.

In the post-Soviet period the branch structure of the RA agriculture underwent significant changes and the branch of animal husbandry, having traditionally dominant position (about 60 % of gross agricultural production), stepped back possessing 40 % of the gross agricultural production; anyhow in the recent years a considerable growth in the share of livestock branch has been observed in the mentioned structure, particularly in 2018 the specific weight of the branch amounted to 53 % in the gross agricultural production (Statistical yearbook of Armenia, 2019).

The structure of gross agricultural production per braches is introduced in the Diagram 1.

The studies have shown that the rate of per capta pork consumtion has a decreasing tendency, which is mainly due to the reduction of local production sizes, which in its turn is related to the multiple issues raised in the sector.

In this regard it is very important to enhance and consider all the problems in the swine breeding branch, which could enable to increase the self-sufficiency level of the pork producton in the country promoting the increase in the consumption rate of the local pork production, as well as the growth of its share in the consumption structure on the whole, since, along with the economic factor the provision of high quality and safe foodstuff to the population is also of paramount importance. It is obvious that the widespread and large-scale import of the food of animal origin, particularly pork production implies many threats regarding the provision of food and foodstuff safety.

Swine breeding is the most productive and rapidly growing branch in the livestock sector. It is second to none in fat and meat yield. The live weight of a piglet at the age of 8 months grows up to 100 times. Throughout a year more than 2-3 tons of live weight can be developed from a mother pig (sow), in case when yearly 2-3 c meat can be received from a cow. For the gain of 1 kg live weight of a pig 5-6 feed unit (FU) is used, while in case of meat fattening up to the age of 7 months 4-4.5 feed unit is needed, in case when in the cattle breeding 7-8 feed unit for the development of 1 kg live weight is applied. The slaughter yield in pigs is rather high (70 %-80 %) and pork is more nutritious (Kovalenko, 1999). So, 9-10 FU is used for 1 kg beef production, 5-6 FU – for 1 kg pork, 7-8 FU – for 1 kg mutton and 3-4 FU for 1 kg poultry production (Hakobyan and Tchepetschyan, 2012).

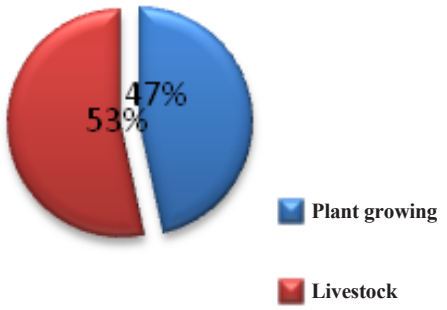
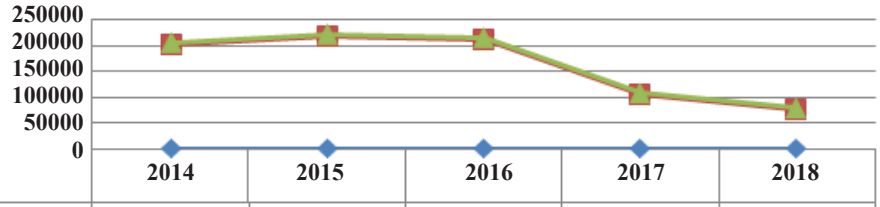


Diagram 1. The values of gross agricultural production per branches (*composed by the authors*).

Crumbled maize is used in the pigs' feed ration in concentrated state; it has also a great portion in the combined concentrated feed (30-60 %). Currently the most maize demand is satisfied by means of import. Particularly, in 2018 the import sizes amounted to 67855.7 tons, the cost of which made 11753.3 thousand USD (Official webpage of the RA customs service), while in the same year the maize croplands covered 1145 land area and the gross yield was 47580 centners (Agricultural croplands and gross yield, 2019). The RA maize croplands, gross yield and the average yield capacity per ha are presented in Diagram 2 (Agricultural croplands and gross yield, 2014, 2015, 2016, 2017, 2018).

Three main directions are identified in the swine breeding branch: meat, bacon and fat production. The studies have shown that meat and bacon productions are more widespread in our country.



	2014	2015	2016	2017	2018
Cropland, ha	2846	3189	3290	2156	1383
Gross yield, centner	201583	217202	210260	104128	75863
Average yield capacity per ha	70.5	68.6	63.9	49	49

Diagram 2. Maize croplands, gross yield and the average yield capacity per ha (*composed by the authors*).

Table 1. Hog number (head) in the RA per regions, 2014-2018*

Regions	2014 h	2015 h	2016 h	2017 h	2018 h
Aragatsotn	10521	10674	14228	15127	12201
Ararat	19434	19447	20959	19770	18586
Armavir	19999	20506	25444	27012	24342
Gegharkunik	11527	12766	15191	15941	16225
Lori	12255	10952	15358	15815	12532
Kotayk	15305	14826	20586	20370	22415
Shirak	13810	12870	14771	18666	14670
Syunik	11686	12364	13730	13467	12533
Vayots Dzor	1890	2418	2627	2519	2185
Tavush	16894	16688	20069	16401	16668
Yerevan city	6478	8921	11813	10461	14400
Total in the RA	139799	142432	174776	175549	166757

*Food Security and Poverty, 2017, 2018, 2019

Prior to transitional period swine breeding was organized in the large complex farms, i.e. in the collective and state farms, on the background of imported feed base. After declaration of independence in the large and mid-sized farms the mentioned branch was inefficient and didn't receive sufficient finances, whereas in the current conditions significant investments are required for the high-tech branch organization. There isn't any relative privilege in the swine breeding branch in Armenia, at least for a short-term perspective, since the major part of the feed product is still imported (RA strategy of sustainable agricultural development, 2002).

Before privatization 98 % of the hog number in Armenia belonged to large white breeds, the other breeds (Duroc, Landrace, Welsh) were used for cross-breeding. In 1994 the Armenian meat pig breed was introduced, which fastly got spread in the republic and according to investigations it makes 9-10 % of the current hog number (RA strategy of sustainable agricultural development, 2002).

All regions (marzes) and almost all rural communities of our republic are engaged in swine breeding. The hog number per RA regions for 2014-2018 is introduced in Table 1.

Upon the analysis of the data introduced in Table 1 it becomes clear that the hog number grew up as of 2014-2018, anyhow in 2018 it was reduced as compared to the data recorded in 2017 by 8792 heads or by about 5 %, which entailed to the reduction of pork production sizes. Due to the decrease of hog number and meat production sizes the index of self-sufficiency level in pork production for 2018 also fell down by 4.7 % against the same index recorded for 2017. According to the average data of the RA national food balance the same index was estimated 57.5 % for 2014-2018 (Statistical yearbook of Armenia, 2019, Food security and poverty, 2019). The indices of pork production, its import and self-sufficiency level for 2014-2018 in Armenia are introduced in Table 2.

The data of Table 2 indicate that the main part of the pork demand is satisfied at the expense of import, which, as to our assessments, is a serious problem from the economic, social and healthcare prospects due to insufficient quality and secure local pork production.

Table 2. The indices of pork production, its import and self-sufficiency level in the RA for 2014-2018*

Year	Production (thousand tons)	Import (ton)	Self-Sufficiency (%)
2014	16.2	7246.8	54.2
2015	17.5	6429.5	57.8
2016	18.0	5659.0	64.1
2017	16.6	7027.2	58.0
2018	16.3	8899.4	53.3
Average	16.9	7052.4	57.5

*Statistical yearbook of Armenia 2019, Food security and poverty, 2017, 2018, 2019

Table 3. The import of pork in the RA per different countries for 2015-2018*

Country	2015, ton	2016, ton	2017, ton	2018, ton
Belarus	-	-	54.8	289.9
Brasil	4658.4	3881.3	5816.9	7764.1
Belgium	124.3	48	71.9	-
Germany	128.6	28	224.7	-
Italy	30	61.4	52.7	46.2
Canada	101	-	126.9	75.1
Norway	-	470.4	395.6	225.1
Ukraine	315.3	608.8	40.3	-
Russian Federation	31.3	142.3	282.5	744.8
Total	5388.9	5240.2	7066.3	9148.2

*Official webpage of the RA Customs Service

The data on the pork import into Armenia and on the import sizes per different countries are presented in Table 3.

The data presented in Table 3 testify that within 2015-2018 the considerable part of the pork was imported into Armenia from Brasil respectively making 86.4 %, 74 %, 80.9 % and 85 % of the total pork production.

Investigating the foreign markets and world practice it becomes clear that the low level of feed provision is the key problem for different countries enagaged in pork production, including Armenia, which is related to insufficient level of feed production and to the high feed prices in the foreign markets. Due to the aforementioned issues severe pork price volatility and significant price variations per countries are observed in the foreign markets, which are mostly conditioned by the shortcomings in feed production field. So, there are rather favorable conditions for the development of swine breeding branch and for the provision of its competitiveness in those countries where the cultivation of cereal crop complex is developed. Based on the mentioned circumstance it becomes quite obvious that due to the underdeveloped cereal crop complex in the Republic of Armenia, as well as to the insufficient level of feed production there are serious obstacles for the development of swine breeding branch. Particularly, per the data obtained for 2014-2018, considerable reduction of cereal and legumunious croplands was recorded. The dynamics of cereal and leguminous croplands and hog number for 2014-2018 is introduced in the Diagram 3 (Statistical yearbook of Armenia, 2019).

Since January 1997, 10 % customs duty is defined for the import of animal-based products, particularly for pork import, which has also exerted an adverse effect on the competitiveness of the local pork production. The studies have shown that due to the low level of population's purchase capacity the preference area in the pork consumption market is mostly towards the imported product, since it is significantly cheaper than the local pork

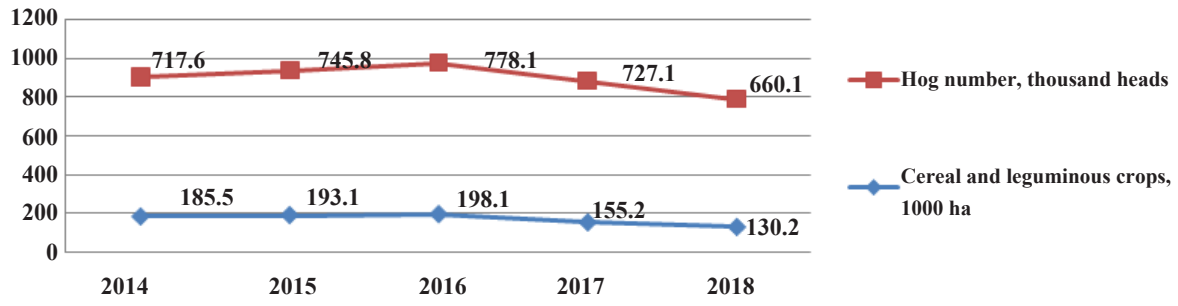


Diagram 3. The dynamics of cereal and leguminous croplands and hog number for 2014-2018 *(composed by the authors)*.

price, which has surely a negative impact on the extension of the local product industry. The high price of the local pork is conditioned by the high cost price of the production process, since the feed expenses take a great share in the overall production costs, which in its turn is again related to the insufficient level of local feed production. There are also many obstacles for import, which have obviously emerged since the proclamation of independence.

As a matter of fact, during the years of Soviet period, the factual annual combined feed consumption made 0.7-0.8 mln tons in the republic, the considerable part of which belonged to the imported product, nevertheless in the recent years the mentioned index has dropped in about ten times.

Based on the abovementioned we can state that the swine breeding branch of the RA can't have a relative privilege at least for a mid-term perspective, since the main part of feed is imported from abroad and related to the import liberalization the imported pork price is rather affordable; besides, the sale system operates inefficiently. As to our analyses, the latter is connected to a number of issues among which the insufficient quantity of specialized structures for pork transportation, storage and sale, as well as the low availability of their rendered services (lack of means for investing the latest technologies for pork storage, packing and containerizing services) are the most important ones.

Along with the issues related to the development of feed production, sale system and feed base there are also other problems viewed in the context of swine breeding development, the complex solution of which can be real only in case of successive development of interrelated units in the mentioned sector. This particularly refers to the design and introduction of cluster model for the branch development.

Cluster is a group of interrelated enterprises centralized in a certain area (equipment, staffing, suppliers of professional services, general infrastructures, scientific-research and teaching centers, etc.), which complement each other and increase the level of competitive advantages for both individual enterprises and for the whole cluster (Yakobson and Kirilova, 2015).

The implementation of adequate measures by the state and local self-governing bodies, as well as their active participation in the whole process is an important prerequisite for the establishment and development of the clusters, since the mentioned bodies are just those linking units by means of which strong cooperation and mutual support are formed between the organizations of different sectors participating in clusterization.

Establishment of clusters have become rather widespread, since the mutually agreed activities of the structures acting within the framework of these clusters greatly promote the increase of coordinated activities between state, private sectors and scientific branch.

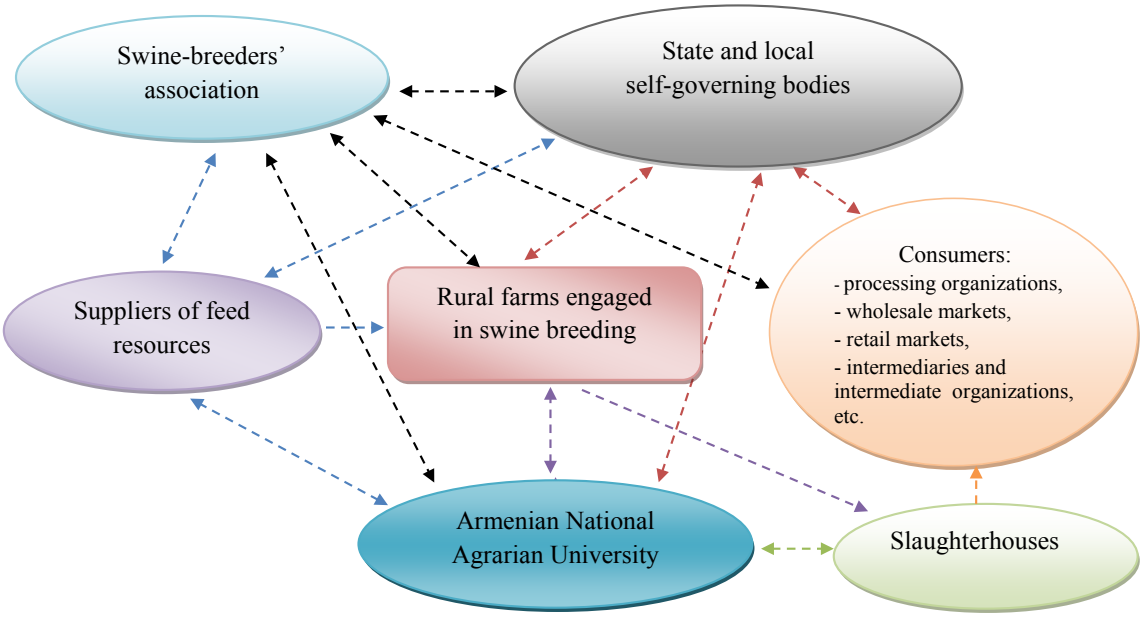


Diagram 4. Cluster model recommended for swine breeding branch (*composed by the authors*).

Based on the aforementioned circumstances and the priorities of branch development, as well as on the peculiarities of the economic and production interrelations, we have designed a cluster model for the branch development, which is introduced in Diagram 4.

Conclusion

The studies have shown that the low level of feed production and feed provision is considered to be one of the crucial issues in the development of swine breeding branch. Thus, we find it urgent and vital to propose conceptual approaches for its increase, upon the application of which it will be possible to significantly improve the situation in this sector for a mid - and long-term perspective. So, the renovation of combined feed production and its mass implementation, as well as the development of relevant activities with the consideration of economic and production resources is of utmost importance. Develoment and implementation of state support programs for the small and mid-sized enterprises engaged in cereal and combined feed production, as well as in that of protein and vitamin supplements is the next recommended approach by our research group. Taking into account that from the prospect of swine breeding development maize is the most valuable and high energy feed among the cereals and the fact that it is more productive than the other crops, we consider that the development of the maize production strategy should be viewed as a key direction in the context of the branch development. The development of the mentioned strategy and the implementation of a specific state policy is an imperative, since the maize croplands have been reduced in recent years, which directly interferes with the development of animal husbandry, particularly swine breeding branch.

Being considered as the most important economic component and the carrier of its development, the clusters can propose efficient pathways for the provision of rapid growth in the branch. It is viewed as a relatively new research field and its establishment and introduction can surely have a considerable effect on the development of the swine breeding branch in our country.

According to the recommended model (Diagram 4) a close cooperation between different organizations of the mentioned branch, various infrastructures, scientific research and teaching centers, as well as between the rural farms engaged in swine breeding is envisaged. Upon the stated interrelations such important issues as the increase of feed provision level, selection of relevant personnel and improvement of their training system, rendering consultatoin services, as well as upgrading of slaughterhouse and sale systems can be handled successfully.

In the recommended clusterization model swine breeders' association is included based on the study of the swine breeding development practice in the Ukraine. So, the Ukrainian association founded on a voluntary basis is an efficiently operating, non-commercial organization. It was established through the unification of the farms from different regions of the country which are enagegd in swine breeding branch. As of 2018, 39 farms of 19 regions were the members of the mentioned association. Among the members there are both large farms and small households and on the whole 100 thousand ha croplands belong to the mentioned farms, which provide 41 % of the pork market. The main goal of the mentioned structure is to introduce and protect the interests of the farms involved in the association, to promote the contribution of the latests technologies in the sector, to expand the sale markets and to protect the domestic producers.

The association cooperates with the processing enterprises, trade organizations, with the centers providing consultations in swine breeding branch, as well as with local self-governing bodies. The main functions of the associations are:

- Providing support in veterinary medicine and animal husbandry,
- Organizing and implementing seminars and courses,
- Studying and analyzing pork market,
- Providing information through different methods,
- Developing and implementing events, etc.

The main directions of the association activities are:

- Providing information and conducting analyses,
- Providing support in educational sector,
- Promoting legal, economic and other types of support,
- Analyzing the current legislation, engaging experts, committees and groups in the process of the study and solution of the raised problems (https://latifundist.com).

We are convinced that the establishment of an association with the mentioned functions and its inclusion in the cluster model can have a favorable effect on the development of the RA swine breeding branch and on the improvement of production and economic relationships; it will also enable to solve the current problems of the swine breeding branch in a more fundamental way.

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The Average Cost of Residents' Diet in Yerevan

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ABSTRACT

Food prices are important in the context of meeting humans' basic needs including diet. Therefore, this study aims to assess the cost of the average diet in the capital of Armenia, Yerevan, where one-third of the population resides. Consumption patterns were studied using a 24-hour recall survey amongst the Yerevan population considering the age range between 18 and 65. Overall, 1264 respondents from 12 districts of Yerevan have participated in the survey. Afterwards, the average cost of per capita monthly diet was calculated and theoretically compared with the healthy diet cost reported in the literature sources.

Introduction

The Republic of Armenia is an upper-middle income country (The World Bank, 2019) which is geographically landlocked and has a diplomatic relationship only with Georgia and Iran from the neighboring countries. Its population is estimated around 3 million, one-third of which resides in the capital, Yerevan (FAO, 2019).

Even though there have been multiple reforms in the country and the economic progress is noticeable, the overall growth has been weak. The level of self-sufficiency in the country is 64 % regarding the most important food, which mainly includes potato, fruits and vegetables. Overall, in terms of the food's self-sufficiency, Armenia is a net food importer and the prices of the food items are highly dependent on the international prices (WFP, Armenia: Cost of the Diet, 2018). Around 23.5 % of the population was living below the poverty line back in 2018 and 16 % of the whole population was food insecure, while the same indicator in 2008 was 8 % showing a worsening situation in the country (NSS, Armenia-Poverty Snapshot over 2008-2018, 2019). In general, the high percentage of the household members was included in the profile of the insecure households among the unemployed household heads and members who are lacking proper education (NSS W. C., 2017).

Generally, the households or individuals which are food insecure have also poor dietary patterns, since they tend

to buy food products by considering quantity rather than quality (WFP, 2018). Among the significant reasons of poor dietary patterns, the income-related burdens should be highlighted.

According to the data published by Statistical Committee of the Republic of Armenia the regional average salary per person is almost uniformly distributed. In 2018, the average annual nominal salary in the Republic of Armenia was 172727 AMD and 190958 AMD in the capital city of Yerevan. Under these conditions, the nutritional diet may not be affordable and people may spend a big proportion of the salary for the healthy food consumption. If individuals are not able to afford a nutrition-rich diet, they don't have another choice rather than the energy-dense food consumption. Fats and oils, added sugars, refined grains, potato chips are considered as energy-dense food, which provide calories at the lowest cost, while low energy-dense foods include meat, fish, vegetables and fruit, which are relatively expensive especially for the vulnerable layers of the society, who receive middle or low salary.

The assessment of the food and nutrition along with the individual expenditures are vital to get information about the population's well-being and nutrition status. Many food scientists and economists have covered this topic in their research papers and tried to compose a healthy diet structure, which is acceptable in terms of the food's nutritional and energy values (Ghazaryan, 2018). These recommendations are particularly important for the individuals whose food consumption patterns compose a big share of their income. Those people represent more vulnerable layers of the societies who have an income status from low to upper-middle level.

Currently with the rapid improvement of technology more models and methods are developed by the scientists and researchers, whose ultimate goal is to provide a hypothetical diet, the cost of which is minimized and the nutritional value of the foods included in it is maximized. One of the most widely known methods is the "Cost of the Diet" method developed by the "Save the Children" NGO, which applies the linear programming to recommend the acceptable amount and combination of the foods that meet the needs of energy, micronutrients and macronutrients intake among individuals (Global Nutrition Report, 2019).

Taking into consideraton the aforementioned information, it is important to understand whether the residents of Yerevan can afford themselves to purchase healthy food and decide the proportion of the cost within the spending. Therefore, the main objective of this study is to assess the cost of the average diet in the capital of Armenia, Yerevan. The data analysis conducted in the frame of this study is aimed at tracking the average daily consumption of an individual, calculating the average cost of the consumption per day based on the data acquired.

Materials and methods

Collection of food consumption data

The food consumption data collection was conducted from 2018-2019 including all the months, since the diet of the population is influenced by the seasonality. Food consumption survey has been designed and conducted by the Informational-Analytical Center for Risk Assessment of Food Chain of CENS. The survey has been conducted with one of the most widely used methods, namely the 24-hour recall method.

Two important points should be particularly mentioned as advantages of this method:

- The 24-hour recalls take the seasonality and food availability into consideration
- It allows collecting some additional information such as timing, frequency, brands which can be very useful for the study (FAO, 2005).

The 24-hour recall questionnaire is usually composed of the list of foods and beverages along with the drinking water and sometimes the food supplements as well, which had been consumed during the previous day or during the 24 hours prior to the recall interview. Not only do these surveys generally collect information about the types and amounts of food consumed, but also about the source of the foods such as whether they were bought from the grocery stores, cooked at home, etc (Nutritools, 2020). It also collects information about the time of the day and place where the foods are consumed. The abovementioned information is received due to the help of the interviewer, who recalls that with a memory, who is also trained beforehand for providing the necessary information.

The number of respondents in the survey is 1264, who live in the capital city of Yerevan (respondents from all 12 districts have been included in the study). The surveys have been conducted with the face-to-face option and anonymously. The questionnaire was composed of general demographic questions such as the name of districts of respondent's residence, age, gender, weight, height, education (higher or other), specialty as well as whether the respondent follows a specific diet (e.g. vegetarian, vegan, special diet for losing some weight or fighting against some diseases). The respondents mentioned the number of the members in their households and also provided the average monthly income with a range. It is worth mentioning

that the age range of the respondents was from 18-65. Data treatment and statistical analysis has been done using SPSS software.

Collection of data on consumed food prices

In the frame of this study the data on prices (AMD) of the consumed foods per kg (as of 2019) were collected. The prices were taken from the Statistical Committee of Armenia (NSS, Price and Price Indexes, 2020), if they were available, and in case of the missing prices, the average market price of the products was calculated collecting them from two of the biggest supermarket chains "Yerevan City" and "SAS" (online store). The price of the consumed food per kg was converted to the price of food per gram.

Diet cost assessment

The average cost of residents' diet in Yerevan was evaluated multiplying the price (AMD) of food per gram by the average daily consumption of that particular food item in grams.

Results and discussions

The data on the average daily consumption of food products in Yerevan is presented in the Table. They provide valuable information about the dietary habits among the study population.

Table. Cost of the average daily food consumption, AMD*

Food product	Average daily consumption (gram per day)	Average price as of 2019 (AMD per kg)	Average cost of the daily diet (AMD)
1	*2*	*3*	*4*
Bread	210.7	468	98.6
Rice	21.3	775	5.5
Buckwheat	39.2	565	11.1
Grain wheat	9.2	515	2.4
Pasta	46.8	547	10.6
Waffle and cookies	8.5	1195	10.2
Milk	69.0	418	28.0
Plain yogurt	40.0	450	18.0
Sour cream	27.5	1142.5	31.5
Cheese	21.6	2193	47.3
Cottage cheese	21.1	2550	53.9
Ice cream	16.6	1694.5	28.2
Butter	6.4	5070	32.4
Spread	2.3	1112	2.6
Potato	116	270	31.3
Watermelon	45.0	231	10.4
Melon	8.0	334	2.7
Apple	35.0	457	16.0
Pear	3.5	1119	3.9
Apricot	7.5	250	1.9
Peach	4.5	310	1.4
Plums	3.2	220	0.7
Cherries	3.5	520	1.8
Grape	18.0	680	12.2
Strawberry	4.2	500	2.1
Cabbage	31.2	183	5.7
Cauliflower	2.3	150	0.3
Frying greens	10.3	1200	12.4
Mixed Greens	7.3	1200	8.8
Cucumber	45.0	400	18.0
Eggplant	16.0	170	2.7
Pepper	14.0	300	4.2
Green bean	12.8	400	5.1
Pumpkin	1.6	250	0.4
Marrow vegetables	3.8	150	0.6
Tomato	63.0	157	9.9
Carrot	5.3	190	1.0
Beetroot	1.6	230	0.4
Onions	8.9	324	2.9
Banana	8.5	630	5.4
Persimmon	3.3	1500	5.0
Orange	5.4	645	3.5
Tangerine	7.6	725	5.5
Beef	50.5	3060	154.5
Pork	14.1	3035	42.8
Chicken	41.26	1595	65.8
Sausage	4.1	1900	7.8
Pork sausage	8.4	2200	18.5
Pelmeni and khinkali	2.1	1150	2.4
Fish	7.9	1670	13.2
Egg	29.0	1320	38.5
Coffee (Dry)	13	2500	32.5
Sugar	11.3	291	3.3
Total average cost of the daily diet			935.46

*Composed by the authors

Based on the combination of the data on food prices and daily consumption among Yerevan's adult residents, the average daily expenditure on their diet is calculated to be equal to 935.46 AMD. Furthermore, the monthly expenditure on the diet will be 28100 AMD. Hence, people who earn minimum salary of 68000 AMD, have to spend 41.3 % of salary for the food intake. Indeed, this indicator is not the desired one, because apart from the food, people have other needs and wants and the leftover of the salary after the food consumption will be very small to meet the basic human needs: clothing, entertainment, education, etc.

It is worth mentioning that at the end of 2018 the Statistical Committee of Armenia reported the minimum consumer basket as 61113 AMD in the Republic of Armenia and out of this, 34527 AMD composes the food basket; however, for the same year, the World Bank reported that the food basket costs 27807 AMD (Haroyan, 2019).

In addition, a study on the cost of the healthy diet proposed a model, which meets the basic nutritional requirements of the individuals and the diet cost (Ghazaryan, 2018). According to the study $ 2.00 is necessary to apply the general recommendations for the Dietary Reference Intakes (DRI), which does not take the age and sex into consideration. Therefore, the monthly cost for the proposed model is $ 60 or 28824 AMD. In other words, this model is slightly more expensive than the actual consumption that we have calculated. This is an important conclusion, which states that the residents of Yerevan can afford themselves buying healthy food which is nutrition-dense rather than energy-dense. However, do they usually consume nutritional food given the amount of money found? Based on the data provided by the National Statistical Committee of Armenia on the food basket, the cost of the average daily food consumption of our respondents through the 24h recall method and comparing them with the cost of the proposed model mentioned above, we can state that people can have a food intake, which is healthy.

However, a further research should be done to ensure that these foods which are consumed by the individuals participated in surveys correspond to the dietary recommendations for the healthy food, which contains the sufficient amount of micro and macro nutrients, energy and so on. In essence, even though the cost of healthy diet is close to the cost of actual consumption among the individuals, there is a risk that foods consumed by those people is not healthy enough and doesn't contain the necessary vitamins, micronutrients or vice versa, they may exceed the amount of some elements necessary for the daily intake. The reasons for the associated risk are but not limited to the level of education, lack of the care, cultural perspectives, people's tastes, preferences and so on.

Conclusion

In this research paper we compared the actual cost of the consumption with the numbers provided by the National Statistical Committee of Armenia and the World Food Program. Factually, the average monthly food consumption calculated is not very different from the cost calculated by the abovementioned organizations. However, the concerned issue regarding the results is that the actual consumption doesn't take the nutrition into account. Therefore, further research is necessary to cover the nutritional part of the diet as well to explore whether Armenians can afford themselves to buy healthy food, which will not cause health problems.

Based on the findings of this study, we recommend increasing the awareness of healthy diet among population through different mediums, such as social media, TV, Radio, etc. Another recommendation is for the Government to review and increase the minimum salary (wage) of the population, so that they can also spend some proportion of their income on other things: entertainment, education, clothing or just for saving. Also, the Government can adopt some assistance programs for the low-income families involving the private sector in the programs as well.

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Investment Outlook: Production and Processing of Soybean in Armenia

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ABSTRACT

The aim of this paper is to present a perspective microbusiness opportunity by introducing new products for Armenian market. Those products are soymilk and tofu. They are plant-based dairy alternative products and are viewed as one of the best substitutes for dairy products. The scope of this paper examines a close-cycle production suggesting potential investors in this field to inhouse all the value-chain stages. Overall, 34200 USD of capital expenditure and 12400 USD investment in working capital is required to run a business. The calculations show that after 5 years this type of investment opportunity promises 67700 USD of NPV and 57.3 % of IRR with 1.8 years payback period.

Introduction

Although there are significant technological changes in agricultural production and processing worldwide, the problem still exists for some segments of population in Armenia to find appropriate food alternatives corresponding to their needs. This paper introduces quite new products for Armenian market. These are plant-based dairy alternative products: soymilk and tofu (cheese made from soymilk). Soy-based dairy products are almost super substitutes for protein containing animal-based products, since they contain huge portion of protein (Arnarson, 2019).

The main and popular sources of protein are animal-based food like meat, egg, dairy products, etc. On the other hand, there are specific groups among the population who could not consume such kind of products because of physical, psychological or cultural reasons. Eventually, they are not getting the extremely important nutrition for their organisms. Vegans are the main segment of population who do not use any of these products and somehow they should fill in the protein ration in order to follow healthy lifestyle. Some people are lactose intolerant, that is they have troubles in digesting a sugar called lactose, which is the carbohydrate found in cow's milk (Migala, 2019). Since soymilk and tofu originated in Eastern countries, the main consumers of these products are Indians and Chinese. During the last several years, the number of Indians is constantly growing in Armenia. Soymilk and tofu are widely used and popular products in the world. Western countries are also major consumers of soy product. Year

by year Armenia is becoming more popular country for tourists. The increasing number of tourists expands the soymilk and tofu market sizes. The industry, opportunities in the market, operations and financial aspects are further discussed in detail. All the estimations and calculations examined in this paper are based on the projections and forecasts for the first 5 years.

Materials and methods

Soybean

In 2019, 336.5 million metric tons of soybean was produced worldwide (The Soybean Processors Association in India, 2019); 100 g of boiled soybean contains 63 % water, protein: 16.6 grams, carbs: 9.9 grams, sugar: 3 grams, fiber: 6 grams, fat: 9 grams, saturated fat: 1.3 grams, monounsaturated: 1.98 grams, polyunsaturated: 5.06 grams, omega-3: 0.6 grams and omega-6: 4.47 grams (Arnarson, 2019).

For 1 hectare of soybean production, the inputs are the following: soy seed - 60-90 kg, phosphorus and calcium fertilizer - 60 kg, nitrogen fertilizer - 45 kg, "Kristalon" - 2 liters, "Maxim XL" - 1 liter/ton, "Regent" - 10 liter/ha, "Pantera" -1.5 liters. The vegetation period lasts 75-200 days. Soybean yield is 2.5 tons per ha (Ministry of Agriculture of the Republic of Artsakh, 2018).

For production purposes, soybean is not cultivated in Armenia yet. However, there are several small soybean plants, which are used for scientific experiments (Ministry of Agriculture of the Republic of Artsakh, 2018).

Soymilk

Soymilk is the best substitute for cow milk among plant-based dairy alternative products, since it contains approximately the same amount of protein. Also, soymilk is considered to be as a healthy food for diabetics and people who are in diet, since unflavored soymilk contains negligible quantities of sugar and low calories. Soymilk is also preferred by heart patients, since it lowers bad cholesterol level. It is naturally lactose-free and rich in iron (MACMILLAN, 2018).

The 225 g soymilk contains 80 to 100 calories, 4 grams of carbohydrate, 1 g sugar, 4 g fat, and 7 g protein. It also contains potassium, calcium, vitamins A, B-12, and D (Industry Europe, 2019).

Plant-based dairy alternative products have also environmentally positive impacts in terms of land and water use as compared to the cow milk. Production of almond, oat, rice and soymilk reduces carbon emission about three times and decreases land utilization rate (Oakes, 2020).

The main ingredients for soymilk production are water and soybean. For producing 1 liter of soymilk, 100 g soybean is required.

Tofu

Tofu, cheese made from soymilk or soya curd, is produced by curdling soya milk with a coagulant. It is nutrient rich, easy to digest, cholesterol reducing and isoflavones-rich product having all the useful characteristics as soymilk. In order to make 300 grams of tofu, 1 liter soymilk is needed (Soya 2020).

The main ingredient of tofu is soybean. In refrigerator tofu can be kept up to 60 days (Frey, 2019).

Production leftover

While making soymilk, production leftover appears in the form of curd. It is a protein-rich mass which the majority of producers just throw away. Nevertheless, the others use it to make other soy products like cottage cheese, etc. For the examined investment opportunity, it is suggested not to throw away the production leftover, since it is considered to be very nutritional animal feed. It can be used in the farms, animal shops or in Yerevan zoo. The quantities of production leftover are very limited. After producing 100 liters of soymilk, only 4 kg of leftover appears.

Industry overview

In 2018 soymilk market value amounted to 15.33 billion USD worldwide. In 2025, market value is forecasted to be 23.2 billion USD (Shahbandeh, 2018, Market value of soymilk worldwide from 2018 to 2020). The CAGR of soy beverages market in Asia-Pacific region is expected to grow by 5.9 % during 2018-2023 (Shahbandeh, 2018).

For Armenia, soymilk and tofu are new products in the market. However, soybean is widely used in food manufacturing industry, particularly in meat processing factories as an important ingredient. Soybean is imported to Armenia. The quantities and prices for the last 19 years are presented in Figure 1.

It is visible that import quantities and prices had cyclical pattern during the last 19 years. The maximum quantity, 1537 tons of soybean, was imported in 2005 and the minimum quantity of import was in 2016. So, the import quantities and prices are forecasted to be mainly the same

during the upcoming 5 years. The quantities vary from 20 to 23.8 tons and the price per ton is approximately 520 $ (in the boarder, without tax, transportation, overhead and other costs). The CFD data, generated from simulated results, have shown that the chance of import price being higher than expected price is 60 %.

The research was conducted in Yerevan's supermarkets and big retail stores. Tofu was not found in any supermarket or store. Only imported (from Germany) soymilk was noticed in "SAS" supermarket with a very high price (1450 AMD). The producer is "Alpro GmbH" multinational company.

In addition, a survey was conducted with randomly selected 150 respondents. It has shown that more than 80 % of population has no information about soy products and approximately 30 % hasn't even heard anything about soybean. After additional informative description about characteristics of soy products, the question was asked to respondents: "Would you switch from dairy products consumption into soy-based dairy alternative products?" The results show that people are mostly ready to switch from dairy products consumption into soy products if the taste (48 %) and price (28 %) were preferable for them.

Target market

Protein is considered to be one of the most important nutrition for people's health. The daily requirement for protein depends on age, weight, sex and other factors. Animal-based products like meat, egg and dairy products are the main sources of protein. However, there are specific groups among the population who could not consume such kind of products because of physical, psychological and cultural reasons. In order to fill in the protein requirement and get the important nutrition, these people consume plant-based products, which are considered to be a source of protein. Soy is one of the richest protein containing plants and different products made from soybean are widely used across the world.

The direct target group for soymilk and tofu are vegans who do not use any animal-based food. Somehow, they should fill in their protein ration in order to follow healthy lifestyle. There are more than 47 vegan or vegetarian cafes and restaurants in Armenia. They are considered to be a direct market, where the targeted customers can be found. By comparing Armenia with other countries with the same sizes and culture, it is estimated that approximately 2 % of population in Armenia are vegans or vegetarians.

Some people are lactose intolerant, which means that they have troubles with digesting a sugar called lactose, which is the carbohydrate found in cow milk (Migala, 2019).

About 15 %-30 % of population in Armenia is lactose intolerant, which means that they exclude cow milk from their food ration (NOBBS 2020). Those are considered to be in the target group for soymilk, but for the initial stages it is not suggested to include lactose intolerants in direct target group. However, they could be still viewed as a potential market and in long run could be included in the target group. Another potential market to be targeted are Indians (living in Armenia), since soymilk and tofu originated in their region and are the important ingredients in their cuisine and culture. In 2019, approximately 15000 Indians migrated to Armenia for work.

Soymilk and tofu are widely used and popular products in the world. It is forecasted that soymilk market would boost in the coming years (Grand view research, 2019).

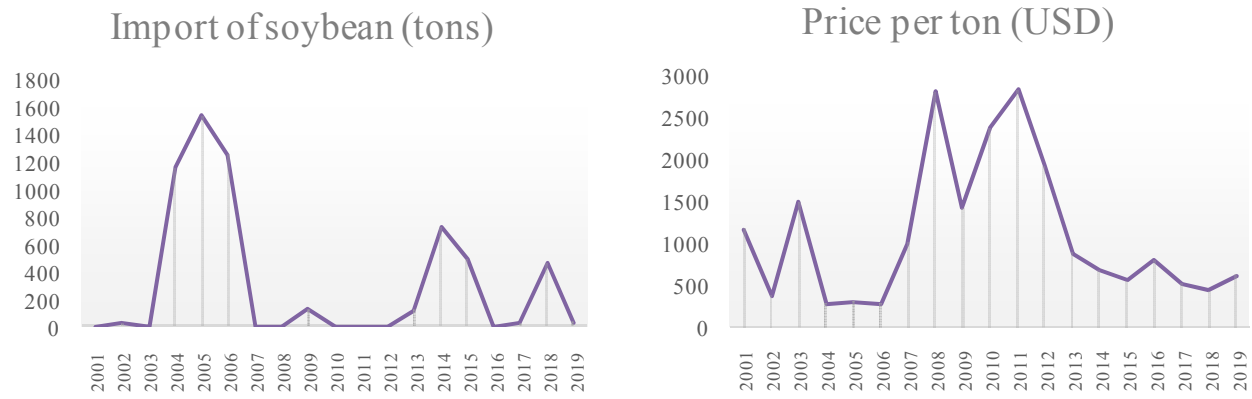

Figure 1. Soybean import quantities and prices per ton (2001-2019) (*Statistical Committee of the Republic of Armenia (2001-2019)*).

More and more tourists are visiting to Armenia each year. Some part of the tourists might be soymilk or tofu users. So, the tourists are also considered to be a part of target group. In 2019, the total number of tourists visiting to Armenia was 1894377 (Ministry of Economy of the Republic of Armenia, 2020).

On average 6 % of tourists visiting to Armenia are expected to be vegans or just soy products' customers. So, the increasing number of tourists expands the soymilk and tofu market sizes. It is calculated that the total demand in the market for soymilk in Armenia is 760 liters (excluded lactose intolerant people) and for tofu 380 kg per day. The calculation is shown in Table 1.

Vegans are mainly found in Yerevan. As was mentioned, approximately 2 % of population in Armenia are vegans. The population in Yerevan in 2019 was 1081800 and 2 % of it was equal to 21636 vegans. According to the Ministry of Economy of the RA, the number of tourists visited to Armenia in 2019 was 1894377. On average 6 % (113663) of tourists visiting to Armenia are soymilk and tofu users. In 2019, 1907 Indians were registered in Armenia by getting living right. In the same year, 15422 Indians migrated to Armenia as workforce. They spent approximately 8 months in Armenia, from March to October.

On average, Armenians consume 20 liters (50mg daily) of cow milk and 10 kg (25 g daily) of cheese annually (Statistical Committee of the RA, 2019). Since soymilk and tofu are new products and market needs to adapt to these products, the expectations regarding to consumption rate are not the same as cow milk and cheese. The expectations are a little bit pessimistic and it is anticipated to have 20 g of daily soymilk consumption and 10g of tofu consumption in Armenia.

Production and sales volumes for the 5 years

For the first 5 years, the assumption was made to cover 25-30 % of the total demand given the capacity to produce 630 liters of soymilk daily. Because it is unknown how the market will react to the new products, for the first 4 year company will produce less than its maximum capacity and in the 5th year it is going to produce in its maximum. First year of operations, by covering 25 % of market, 200 liters of soymilk and 90 kg of tofu should be produced daily. Each year the production is going to increase by 6 % since more and more people will be informed about soymilk and tofu. Production quantities are shown in Table 2. They are in line with the monthly demand.

Operation plan

Before starting the operations, there is a need to obtain the following assets: land for soybean cultivation, building for organizing the production and warehousing the soybeans, soymilk and tofu making machine, bottling machine, refrigerator for keeping the inventory, other equipment and materials used for production, a vehicle with refrigerator for final product delivery and other non-tangible assets like certification, company's logo, design, etc. Since it is a microbusiness opportunity, the capital expenditures are minimized. For example, in order to promote plant cultivation, government provides agricultural rental land for 99 years with a very affordable and attractive price. So, instead of making large capital investment and buying 10 hectare land, it is better to rent land for soybean production. First, it is cost effective, second in case of losses the business will be liquid and could quickly shut off. The soymilk making and bottling machines will be imported from Russia. The capacity of soymilk and tofu making machine is 80 liters per hour spending 10.5 kw electricity.

Table 1. Daily demand for soymilk and tofu in Armenia*

Target groups	Number of people in targeted market	Daily use of soymilk (liter)	Daily use of tofu (kg)
Vegans	21 636	432.7	216.4
Tourists	113 663	87.2	43.6
Indians	1 907	38.1	19.1
Indian workforce	15 422	202.8	101.4
Total	152 627	760.8	380

*Composed by the author.

Table 2. Production volumes for 5 years*

Production Volume					
Product	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Soymilk (liter)	150 000	159 000	168 600	178 500	189 000
Tofu (kg)	27 273	28 909	30 727	32 636	34 727
Production leftover (kg)	6 000	6 360	6 744	7 140	7 560
Soybean (kg)	10 000	9 100	8 140	7 150	6 100

In order to start operations, 120 sq. meter building including production, warehouse and office area is required.

The cost for 1 ha soybean production is 1240 USD. After harvest in November, the soybeans can be transported to warehouse. Then, the main production of soymilk and tofu can start. Since working day is 8 hours, the maximum daily capacity for making soymilk is 640 liters. For making 1 liter of soymilk 100 grams of soybean needs to be grinded with water. After grinding process, the soymilk making machine boils the milk with steam, then by filtring the mass, machine gets the final milk. Meanwile, during the process some extracts could be added into the milk in order to change the specific smell of soybean. After producing the soymilk, the predetermined quantity passes to the next stage of production. The milk as final selling product goes to bottling process and the rest goes to tofu making process. After bottling, soymilk goes to refregirator room.

For tofu preparaion, coagulant is added to the milk, with gently stirred soymilk to be mixed for 15 minutes. After small white curds of tofu appear in an amber liquid, it is time to transfer the coagulated dispersion into a mould lined with cheese cloth. After water filters from curd, the mass should be held under pressure about 20 minutes with the special form. In order to give extra texture to tofu, it needs to be covered with water and taken to refrigerator. In order to make 300 grams of tofu, 1 liter soymilk is needed.

As a result, 20 kg of production leftover appears in the end of each day. Every day the produced soymilk, tofu and production leftover can be delivered to distribution centers. Soymilk could be delivered to fitness clubs, hotels, coffee shops, big supermarkets and some small retail stores located in the areas where Indians usually live. Tofu would mainly be delivered to restaurants, hotels and again the same stores where soymilk is delivered. After each year, the unused soybean will be sold to food manufacturers, specifically to meat processors. The total soybean yield is expected to be 25 tons yearly (2.5 tons per hectare).

Marketing activities

Soymilk and tofu are in introductory stage and by entering the market producers should start actively inform the targeted customers about characteristics of product. As was mentioned, the target groups for soymilk and tofu customers are vegans or vegetarians (both local population and tourists) and Indians living in Armenia. It is calculated that approximately 167000 USD is required to spend on marketing campaign for the first 5 years of operations. The budget is preferable to spend on website development, local events, where the business could present itself against business community, targeted social media marketing, participating and presenting products on TV shows related to cuisine, participation in international expos twice a year in order to be informed about the latest developments, new players and overall trends in the market. The proportion of each marketing activity is shown in Figure 2.

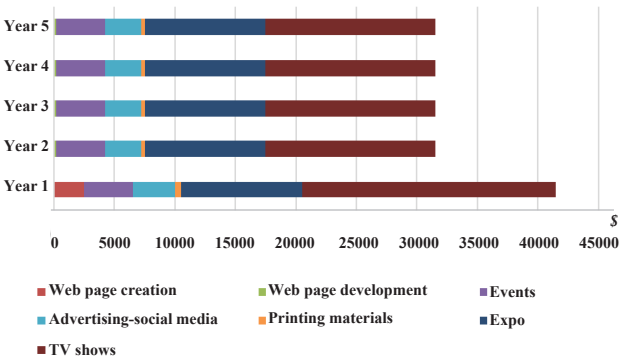

Figure 2. Marketing expenses *(composed by the author)*.

Risk assessment

Soybean production and its further processing for making soymilk and tofu contain mainly external risks. The main risk is associated with market reaction to soymilk and tofu, since they are new products for Armenian market. Even though the active marketing campaign would start in early stages of the business, however market may not accept them.

The business model was developed based on the assumption that each year the entity would cultivate the soybean and then use it for soymilk production in the next year. Soybeans will be cultivated in open field and there is always risk of loss because of plant diseases, weather instability, etc. There is no insurance package in Armenia for soybean cultivation yet. It could significantly reduce the losses. This is the second external risk that is hard to control without insurance. The risk management template is presented in Table 3.

Results and discussions

Soymilk and tofu are the core products presented in this investment outlook paper. This paper suggests organizing a close-cycle production, in view to cultivate soybean for further processing and soymilk production. It will significantly decrease the costs, mitigate several risks and ensure constant high quality products. In the frame of this paper the cultivation of soybean is examined within 10 hectares of land area.

Table 3. Risk management template*

Risks	Consequences	Description	Response action	Risk response	Actions for risk response
Problems with soy production and processing technology	Additional costs to find proper technology, potential losses during production	Low	Needs corrective action within 1 month	Reduce the risk	To talk with the top experts and scientists, try to find the best and most efficient production technologies
Finding relevant staff	Added costs on trainings, retention costs, etc.	Low	Needs corrective action within 3 months	Reduce the risk	Choose staff with relevant education and constantly develop their knowledge and working abilities
Plant diseases and insects	It is a cost to fight against insects and diseases. As a result entire yield could be damaged and cause huge losses.	Moderate	Needs corrective action within 1 month	Reduce the risk	Properly and timely fertilize, irrigate and cultivate the land and plants
Market adaptation	Market could not accept the product, business would make no sales.	High	Does not currently require corrective action	Reduce the risk	Start an aggressive marketing campaign and inform people how useful and healthy goods are soy products
Weather instability	The whole yield could be damaged stopping business operations and causing significant losses.	High	Needs immediate corrective action	Transfer the risk	It is the most uncertain risk in agriculture. For risk mitigation we can start soy production in land which has anti-hail station near it, protect plants from freezing, etc.
Imported low cost soy and soy products	Sales will drop significantly	Low	Does not currently require corrective action	Accept the risk	This is a risk, which we could not control. So the only tool is to be effective in order not to let imported products compete with us.

Table 4. Profit maximization problem with Excel add-in*

Variable values to manipulate	310	100			
Names of decision variables	Profit milk	Profit tofu	SUM		
Objective to maximize	1.109831	2.5976588	603.8135		
Capacity for milk and tofu	1	3.3	640	≤	640
Demand for milk	1		200	≥	250
Demand for tofu		1	90	≥	100
Nonnegative constraint	1	1	0	≥	0

*Composed by the author.

The harvested soybean will be used for soymilk and tofu production. Some portion of soybean will be sold to meat processing companies as an ingredient for their production. Finally, during production of soymilk, very useful, protein-rich production leftover appears which could be sold as animal feed. It will be an additional source of revenue and mitigate the risks of loss.

The target groups for soymilk and tofu are mainly vegans or vegetarians, lactose intolerants, Indians and soybean based product user tourists. Total daily market demand is projected to be 760 liters for soymilk and 380 kg for tofu. Given the demand and capacity constraints, profit maximization problem was solved with "Solver" Excel add-in, which has shown that for the first year 200 liters of soymilk and 90 kg of tofu should be daily produced (Table 4). As a result, 20 kg of production leftover appears in the end of each day. The import quantities and prices of soybean are forecasted (by Simetar Excel add-in) to be mainly the same during upcoming 5 years.

The quantities vary from 20 to 23.8 tons and price per ton is approximately 520$ (in the boarder, without tax, transportation, overhead and other costs). The CDF data, generated from simulated results, have shown that the chance of import price being higher than expected price is 60%. So, comparing with price imported soybean could not compete with locally cultivated one.

Since in this paper microbusiness oportunity is examined, the financial requrements are also humble. For starting the business operations, 34 200 USD capital investment is required. The capital is required to cover the following pre-production costs: purchase of building, repair of the building in order to satisfy all the requirements obligatory for organising food production, machinery and equipment for soymilk and tofu production, machine for soymilk bottling, refregerator for warehouse, vehicle for final product distribution and other marketing and legal costs (certification, company logo, etc.). The costs are presented in Table 5.

Table 5. Capital expenditures (USD)*

Name	m/u	quant	price	Total value
Production area				
Building across Yerevan	Sq.m	120	100	12 000
Repair	Sq.m	120	50	6 000
Total Factory				**18 000**
Equipment				
Machinery for making milk	unit	1	2 037	2 037
Machinery for bottling	unit	1	1 360	1 360
Refrigerator for warehouse	unit	1	200	200
Other equipment			1 000	1 000
Total Equipment				**4 597**
Machinery				
Vehicle	unit	1	7 000	7 000
Total Machinery				7 000
Company logo/design/ certification/other costs				4 600
Total Capex				**34 197**

*Composed by the author.

Besides, for producing soybean in 10 hectare (25000 tons of yield) land area, 12400 USD is required (the cost for 1 ha is presented above). Based on 5-year financial results, net present value (NPV), internal rate of return (IRR) and payback period for this type of business opportunity were calculated. The weighted average cost of capital was calculated to be 14.67 %. For the 5 years' projections, NPV is equal to 67700 USD, IRR is equal to 57 % and payback period is 1.8 years. So, the financial part of the business is more than attractive as it is profitable and IRR is greater than WACC.

Also, soy products open a wide range of creativity in relation with new products' introduction to the market. One of the main reason is the fact that soy milk or tofu themselves have no any specific flavor. They take the smell and flavor of a meal with which they are used or mixed. For example, by frying tofu with meat, tofu would have the same taste as meat. The same process could be organized during soy milk and tofu production processes. Different tastes and smells could be added to products and presented to the market satisfying all the customers' wants and needs.

Conclusion

The successful microbusiness opportunity is presented in this investment outlook. Even though the market and products (soy products) are new for Armenian market, there is an unsatisfied demand in the market for these products. There is a need to actively inform targeted groups about healthy and useful characteristics of soy-based dairy alternative products. Since market is in introductory stage, it is recommended to inform about products as many people as possible in the first 5 years of business operations.

For the start of soybean cultivation in 10 hectares of land area and for its further processing, overall 46600 USD investment is required among which 34200 are capital investments and 12400 USD are working capital expenditures. After 5 years, business NPV is forecasted to be 67700 USD and IRR - 57.3 % which is quite high comparing with 14.67 % WACC.

However, business is closely linked to agriculture and final products (soymilk, tofu) are new in Armenian market, thus, the business contains several risks.

By summing up the business opportunity, the overall impression is positive. It is a real, viable and prospective investment opportunity in the worldwide growing soybean market.

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The Ecological and Toxicological Condition of the Waters in the Sotk and Masrik Rivers under the Influence of the Sotk Mine Exploitation

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ABSTRACT

The article considers the results of the studies conducted on the ecological and toxicological state of the waters in the Sotk and Masrik rivers under the influence of the Sotk mine exploitation.

Upon the investigations it has been disclosed that along with the increase of the mining industry dimensions, as well as rock dump amounts, the organoleptic and chemical indices of the waters in the Sotk and Masrik rivers have also grown up. Due to heavy metals the amount of suspended particles per liter of water has increased over the last 10 years. Taking into account that individual heavy metals (tungsten, vanadium, molybdenum, etc.) are more active in the base medium, it is necessary to install filters for their refining.

Introduction

Sevan basin management area is situated in the eastern part of Armenia. The basin of Lake Sevan makes up one sixth of the total territory of Armenia. Sevan basin management area makes 4721 square km, out of which 1279 square km is covered by the mirror of Lake Sevan ("Armhydromet" SNCO, 2017). Lake Sevan is surrounded by Geghama (from the West part), Vardenis (from the South part), Areguni (from the North-Eastern part), Sevan and Eastern Sevan (East part) mountain chains with up to 3598 m elevation (Vardenis). Sevan basin management area stretches from $39^{0}87'$ to $40^{0}68'$ in the northern latitude and from $44^{0}76'$ to $45^{0}98'$ in the eastern longitude. The maximum length from the south to north makes 90 km, while from the east to west – 103 km. One of the characteristic traits of the Sevan basin management area is that the ratio between the catchment/drainage basin area of Lake Sevan and the area of its mirror is rather small (3:1) as compared to other large lakes (averagely 10:1).

Twenty eight rivers and streamlets (including large springs in the river form) flow into Lake Sevan and only the Hrazdan

river originates from the lake. In general, most of the rivers in the basin of Lake Sevan have less than 10 km length. There are only 6 rivers with 26 km length, while the Argichi river is the only one with more than 50 km length; the rivers Sotk and Masrik, with 10 km length each, are situated in the north-eastern part of the lake and are somewhat fed by the neighboring areas of the Sotk mine.

Mining industry has always been and is still a powerful factor for destabilization of the ecological conditions in the areas of all countries over the world, as a result of which the natural relief and hydrological regimes are disturbed, the vegetative cover is destroyed, a huge amount of rock dumps and technological effluents/waste waters are generated, which are piled up in the canyons and tailing dams; the environment is contaminated with heavy metals and other substances and the population's health is strongly damaged.

Heavy metals are on the top position (28 %) from the prospect of their ecological threats and environmental risk exposure. The world practice evidences that the heavy metals are one of the most toxic pollutants, the danger of which is related to their stability in the external environment, their water-solubility and to the great ability to accumulate in the soil and plants (Galstyan, 2016, Hayrapetyan and Shirinyan, 2003, Harutyunyan and Sargsyan, 2018, Saghatelyan, 2004, Galstyan, et al., 2015).

In the water environment the pollutants can be dissolved, molecular, ionic, coloidal and suspended (Hayrapetyan, et al., 2008, Burenkov, et al., 2001, Budnikov, 1998). Heavy metals pose great danger for the mentioned environment, which appear mainly in the form of suspensions. Unlike the atmosphere, where the retention capacity of heavy metals is not high, the surface waters are mostly considered to be conservative component of the environment. The content of zinc in the surface waters is higher than the content of cadmium by 1-2 degrees; the content of the discussed elements is higher in the surface waters than in the seas and oceans. In the streaming waters about 90 % zink (*Zn)* and 65 % cadmium (*Cd*) are in a suspended state (Sokolov, et al., 2008, Ashikhmina, 2005). Thus, the evaluation of the ecological state and the contamination level of the surface waste waters in general, flowing from the areas of mining industry and from its neighboring territories, as well as the related studies are rather actual and are based on the strategic developmental requirements of the given region; at the same time they have both environmental and socio-economic feasibility and address the interests of population by ensuring their healthcare and safety. Though only ore mining and transportation activities are implemented in the RA Sotk gold deposit (gold mineralization and extraction from the ores is implemented in the Ararat gold flotation plant), laying of the rock dumps appeared throughout the process of the aforementioned activities, the spread of dust and aerosols in the environment through the atmospheric streams, particularly in the waters of the Sotk and Masrik Rivers (the latter are used for irrigation purposes, the rest of the water is discharged into Sevan Lake) situated in the territories near the mining site, cause pollution with different types of ions and heavy metals.

Hence, we have set a task to study and identify the ecological state of these waters and to make appropriate recommendations for its improvement.

Materials and methods

The studies have been conducted through the water sampling from the appropriate observation points of the Sotk and Masrik Rivers situated near the Sotk mine and through determining their organoleptic and chemical indices. It has been planned to determine the dynamics of the investigated elements by comparing the obtained data with the similar indices of the water samples taken from the same observation point by the Environmental Monitoring and Information Center (EMIC), SNCO under the Ministry of Environment within the previous 10 years and to develop the needed recommendations.

Taking into account the circumstance that reoxygenation, as well as physicochemical, biochemical processes and intensive microbial activities, sorption, desorption and other activities are taking place in water and the water organoleptic properties can change, laboratory studies on taste, flavor, color, permeability have been conducted with the standard methods (Shahinyan, 2005, Clesceri, et al., 1998). Hydrogenic index, specific electrical conductivity and salinity have been determined through the electro-chemical method: the total dissolved substances have been calculated multiplying the value of specific electrical conductivity by 0.65.

Biochemical oxygen demand (BOD) represents the amount of oxygen (mg) needed for oxidizing organic matters in 1 liter water at 20 ^{0}C under aerobic conditions over some period of time: in our case it has been determined for 5 days (Shahinyan, 2005, Clesceri, et al., 1998).

Biochemical oxygen demand (BOD) (bichromatic oxidation) has been determined in the acidic medium of potassium bichromate under the guidance of catalysers, while titration has been implemented with 0.025 N solution of the Mohr's salt. It has been determined through the following formula: $C_x = (n_1 - n_2)\ x\ 8\ x\ V_2/V_1\ x\ 1000$, where V_1 is the volume of the investigated water, V_2 is the volume of the potassium bichromate, n_1 is the volume of the Mohr's salt when titrating the zero sample and n_2 is the volume of the Mohr's salt when titrating the sample. In drinking water the rate of BOD makes 15 mg O_2/L, while in the sanitary and irrigation waters it makes 30 mg O_2/L (Clesceri, et al., 1998). Ammonium, silicium, nitrate and phosphorus ions have been determined with KFK-2 spectrophotometry (Shimadzu 1650) at the wavelength of 360-600, 410, 536 and 708 nm respectively. Sulphate, chloride, nitrate ions have been determined through ion chromatography method (DIONEX - 1000), while the hydrocarbonate- through the back-titration method (Clesceri, et al., 1998).

The permeability, flavor, color are technical criteria, which have been determined through the visual and sensory methods. The analysis of the chemical elements (*Li, Be, B, Mg, Na, Al, P, K, Ca, Se*) in the water samples have been conducted through the inductively coupled plasma mass spectrometry (ICP-MS, ICP-MSELAN 9000) in line with the standard of ISO 17294, which is based on the use of argon inductively coupled plasma as a source for ions and the use of mass spectrometry for ion separation and their further determination (Fomin, 2000, Clesceri, et al., 1998, Davydova, 2005).

Results and discussions

Upon the results of investigations it has been disclosed that the organoleptic indices (suspension particles, color and flavor) both in the Sotk and Masrik Rivers, are different depending on the sampling times. The water quality deteriorates starting from May up to November, which is related to the rain and meltwaters, as well as to the intensive atmospheric activities. It is apparent that less amount of suspended particles in the waters of the Sotk and Masrik Rivers are found particularly in the water samples taken from the territories closer to the mining site. Thus, in November 2019, the suspended particles in the water samples taken from the territory situated1km above the Sotk community and opposite the community have made 3.5 mg/L and 11.5 mg/L respectively (Table 1), while in the waters of the Masrik river 1.5 km above V. Shorzha community and opposite the mentioned community it has made 5.5 and 19.9 mg/L respectively; at the friths of the Sotk and Masrik rivers and after interflowing of the waters their suspended particles amounted to 47.5 and 28.7 mg/L respectively (Tables 1, 2).

Table 1. Organoleptic and chemical indicators of the Sotk River waters depending on the exploitation of the Sotk gold mine*

N/N	Indicators	Measuring unit	October-November, 2010				October-November, 2015				November, 2019			
			The indices of cellar pit, October-November	1.0 km above the Sotk community	Opposite the Sotk community	River mouth (frith)	The indices of cellar pit, October-November	1.0 km above the Sotk community	Opposite the Sotk community	River mouth (frith)	1.0 km above the Sotk community	Opposite the Sotk community	River mouth	After interflowing of the Sotk and Masrik Rivers
1.	Hydrogenic index		8.30	8.20	8.40	8.74	8.40	8.36	8.44	8.40	8.43	8.37	8.35	8.78
2.	Dissolved oxygen	mg/L	10.20	9.20	6.40	10.30	9.8	6.40	7.60	6.60	7.20	6.80	9.30	5.40
3.	BOD_5	mgO_2/L	1.80	2.00	1.30	2.20	2.0	2.15	2.18	2.10	1.79	1.00	2.70	1.91
4.	BOD	mgO/L	-	-	18.0	-	15.40	28.0	15.0	27.0	15.0	35.00	17.00	30.0
5.	Total phosphorus	mg/L	0.02	0.01	0.05	0.00	0.03	0.05	0.01	0.05	0.02	0.02	0.01	0.04
6.	Ammonium ion	mgN/L	0.30	0.25	0.19	0.18	0.41	0.14	0.09	0.14	0.23	0.12	0.14	0.19
7.	Nitrite ion	mgN/L	0.01	0.00	0.01	0.01	0.06	0.04	0.03	0.03	0.00	0.00	0.01	0.04
8.	Nitrate ion	mgN/L	0.00	-	1.31	-	0.01	2.23	0.26	2.18	0.37	0.45	3.46	2.44
9.	Phosphate ion	mg/L	0.05	0.05	0.10	0.05	0.07	0.18	0.03	0.17	0.00	0.01	0.17	0.07
10.	Chloride ion	mg/L	2.65	2.34	2.31	8.30	2.45	5.26	1.62	5.13	2.43	3.27	7.96	7.58
11.	Sulphate ion	mg/L	20.40	21.64	28.45	65.11	19.62	30.30	8.46	29.30	6.80	15.75	41.53	43.37
12.	Total dissolved salts	mg/L	239.0	246.4	306.0	299.6	261.4	330.0	202.0	309.0	210.0	230.8	285.0	253.5
13.	Electroconductivity	mSm/cm	829.0	379.0	470.0	461.0	972.4	507.0	311.0	502.0	323.0	355.0	439.0	390.0
14.	Suspended particles	mg/L	6.90	2.70	15.40	1.60	7.80	64.40	5.90	62.40	3.50	11.50	47.50	14.1
15.	Permeability	cm	29	29	30	30	27	29	29	29	26	27	28	28
16.	Color (visual)	degree	4	4	4	3	4	4	5	4	4	4	4	4
17.	Flavor	point	Slight flavour 2	2	2	2	3	2	2	3	3	2	2	3

*Composed by the authors based on the data of Environmental Monitoring and Information Center.

Table 2. Organoleptic and chemical indicators of the Masrik River waters depending on the exploitation of the Sotk gold mine*

N/N	Indicators	Measuring unit	October-November, 2010			October-November, 2015			November, 2019				
			1.5 km above the community of V. Shorzha	1.5 km below the community of V. Shorzha	River mouth	1.5 km above the community of V. Shorzha	1.5 km below the community of V. Shorzha	River mouth	The mouth (frith) of the Karchaghbyur river	1.5 km above the community of V. Shorzha	1.5 km below the community of V. Shorzha	River mouth	0.5 km below the river mouth after interflowing
1.	Hydrogenic index		9.20	9.00	8.49	8.50	8.41	8.14	7.3	7.88	8.38	8.24	7.55
2.	Dissolved oxygen	mg/L	11.40	11.2	10.00	8.90	7.00	7.30	7.9	7.70	4.10	6.70	6.90
3.	BOD_5	mgO_2/L	2.80	2.4	2.80	1.62	1.00	1.33	1.2	1.50	1.05	2.60	2.15
4.	BOD	mgO/L	-	8	5.00	8.00	11.4	18.0	10.4	10.0	30.00	15.00	20.0
5.	Total phosphorus	mg/L	0.01	0.0061	0.1274	0.07	0.09	0.16	0.01	0.03	0.03	0.12	0.27
6.	Ammonium ion	mgN/L	0.10	0.1012	0.1944	0.06	0.06	0.07	0.21	0.06	0.11	0.08	0.14
7.	Nitrite ion	mgN/L	0.08	0.092	0.0276	0.01	0.03	0.06	0.13	0.00	0.00	0.03	0.11
8.	Nitrate ion	mgN/L	-	0.5534	0.4944	0.33	0.56	0.93	0.03	0.26	0.76	1.43	2.76
9.	Phosphate ion	mg/L	0.01	0.0142	0.3390	0.40	0.39	0.37	0.12	0.04	0.07	0.28	0.23
10.	Chloride ion	mg/L	4.35	4.4061	4.6562	3.06	2.62	2.41	1.10	1.19	2.15	3.09	4.92
11.	Sulphate ion	mg/L	11.61	11.69	16.54	5.16	5.81	6.96	10.4	4.06	6.96	15.01	20.97
12.	Total dissolved salts	mg/L	152.1	152.60	156.6	154.0	162.6	176.00	114.2	69.0	146.90	141.00	171.00
13.	Electroconductivity	mSm/cm	234.0	230.60	241.0	236.0	247.4	271.00	118.2	106.0	226.00	218.00	267.00
14.	Suspended particles	mg/L	1.80	1.87	15.80	60.20	23.60	18.50	2.14	5.50	19.90	28.70	19.90
15.	Permeability	cm	31	31	30	30	32	31	31	32	31	32	32
16.	Color (visual)	degree	3	3	4	4	4	4	4	3	3	3	3
17.	Flavor	point	Slight flavor 2	2	3	3	With flavor 4	4	3	3	3	3	3

*Composed by the authors based on the data of Environmental Monitoring and Information Center.

If we compare the mentioned indices with the similar average data of the last previous10 years, it becomes obvious that along with the increase of mining industry dimensions, as well as with the increase of rock dumps amount, the quantity of the suspended particles have also grown up and, as to the mentioned studies, the amounts of the suspension particles per liter of water have increased by 210.2-317.0 % as compared to the water samples taken within the same period in 2010; to be more precise, in waters of the Sotk River they have increased by 32.10 mg/L and in waters of the Masrik River – by 13.2 mg/L (Tables 1, 2). The suspension particles have a great impact on the water permeability, its color, flavor, as well as on its biological and bio-chemical indicators, which is more clearly described in the tables below.

Electrical conductivity is considered to be one of the vital ecological indicators of the surface waters. As we can see from the data of Tables 1 and 2 provided upon the studies of the Environmental Monitoring and Information Center, the values of electrical conductivity in the Sotk and Masrik Rivers grow up for the period of December-March as compared to those observed for the period of Spring-Autumn. The mentioned data testify that in the winter hydrological period the river flow appears from the feeding of ground and underground waters and their hydrochemical quality is formed under hydrochemical influence of just the mentioned waters. Considering that unlike the river waters, the values of electrocunductivity in the waters of cellar pits practically stay unchanged in that period and have 2-2.5 times higher values than those recorded in the river waters, it can be stated that in the period of December-March the hydrochemical composition in the waters of the Sotk river is affected also by the drainage waters of the mining site and cellar pits.

Table 3. Content of individual chemical elements in the waters of the Sotk River by dates*

N/N	Name of the chemical elements	Measuring unit	October-November, 2010			October-November, 2015			November, 2019			
			Above the Sotk community	Opposite the Sotk community	River mouth	Above the Sotk community	Opposite the Sotk community	River mouth	Above the Sotk community	Opposite the Sotk community	River mouth	After interflowing of the Sotk and Masrik Rivers
1.	*Ca*	mg/L	35.09	40.07	50.97	37.91	21.87	28.15	20.35	23.02	46.04	34.32
2.	*Mg*	mg/L	33.63	39.91	29.26	42.14	31.12	30.72	32.56	41.09	19.70	30.39
3.	*K*	mg/L	1.18	1.68	5.49	2.77	0.52	5.47	0.48	0.93	2.07	2.45
4.	*Na*	mg/L	3.06	6.07	11.38	3.83	2.68	10.86	2.72	6.35	7.58	11.70
5.	*Al*	mg/L	0.06	0.03	0.04	0.06	0.02	0.56	0.02	0.02	0.12	0.14
6.	*Se*	mg/L	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	<0.00	0.00
7.	*S*/Sulphur/	mg/L	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01

Table 4. Content of individual chemical elements in the waters of the Masrik River by dates*

N/N	Name of the chemical elements	Measuring unit	October-November, 2010			October-November, 2015			November, 2019			
			1.5 km above the community of V. Shorzha	1.5 km below the community of V. Shorzha	River mouth	1.5 km above the community of V. Shorzha	1.5 km below the community of V. Shorzha	River mouth	1.5 km above the community of V. Shorzha	1.5 km below the community of V. Shorzha	River mouth	After interflowing of the Sotk and Masrik rivers
1.	*Ca*	mg/L	32.43	28.4	26.42	31.96	30.89	30.89	16.45	30.03	28.75	29.36
2.	*Mg*	mg/L	6.61	8.40	9.16	5.82	8.86	8.86	2.31	6.78	7.55	11.22
3.	*K*	mg/L	2.29	3.00	3.30	4.42	4.46	4.46	0.64	2.60	2.95	4.48
4.	*Na*	mg/L	9.04	9.11	9.11	7.86	9.89	9.89	3.33	10.46	5.36	11.92
5.	*Al*	mg/L	0.01	0.03	0.04	0.79	0.06	0.06	0.13	0.11	0.15	0.23
6.	*Se*	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7.	*S* (Sulphur)	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

*Composed by the authors.

The results of the laboratory studies show that in the waters of left-bank tributary of the Sotk and Masrik Rivers, the feeding of which hardly has any relation with the Sotk mine, the average value of electrocunductivity is lower in 2-4 times than the values generally recorded in the waters of the mentioned rivers. For comparison the values of the electrocoductivity in waters of the Karchaghbyur river mouth (frith) have been also studied, which don't have any seasonal variabilities and are 2 times lower than the average electroconductivity value observed in the waters of the Masrik River mouth.

The investigated waters are equivalent to the alkaline waters regarding the values of their hydrogenic indicators (*pH*). Thus, *pH* in the Sotk River mouth (frith) makes 8.78, in the water sample taken from 1.0 km above the Sotk community it makes 8.43, while in the Masrik River mouth it is 8.38 and in the samples taken from the same river, 1.5 km above V. Shorzha community, it makes 8.21. This circumstance is related to the chemical composition of the environmental mountain ores, where the alkaline chemical elements (*Ca, K, Na, Mg,* etc.) are prevailing, the content of which has always been high both in the period of 2010-2018 and in the period of our investigations.

Waters of the Sotk River contain averagely 30.2 mg *Ca,* 1.3 mg *K*, 5.5 mg *Na* and 31.6 mg *Mg* per liter of water, while in waters of the Masrik River the mentioned indices have made 22.5, 2.0, 6.3 and 5.4 mg/L respectively. The

content of *Ca* has made 26.00 mg/L, *K* – 2.60, *Na* – 6.45 and *Mg* – 5.20 mg/L (Tables 3 and 4); the mineralization degree in the waters (total amount of the inorganic compounds) doesn't exceed 1g/L and, per the average data of the previous 10 years, it makes 129.8 mg/L in the waters of the Masrik River and 263.4 mg/L in the waters of the Sotk River, while for the period of our investigations (November, 2019) the mentioned index in waters of the Masrik River has made averagely 146.9-182.0 mg/L and in the waters of the Sotk River it makes 230.8-253.5 mg/L, besides, 95 %-96 % are hydrocarbons; 4-5 % are sulphates, while Se and Al make very little amount. As to the content of nitrate, nitrite and ammonium ions it is clear from the table data that upon the results of the investigations conducted in the previous years and upon the laboratory investigations on the water samples conducted in November 2019, they hardly exceed the standards set upon the decision N 75 on the surface waters assessment, taken on January 27. 2011, by the RA Government, which are as follows: NO_3^- – 45, NO_2^- – 3.3, NH^+ – 2 mg/L and NO_3^- – 0.02-1.5, NO_2^- – 0.001-0.04, NH_4^+ – 0.03-0.7 mg/L respectively.

The data of EMIC testify that for the winter-spring period in the waters of all observation points the concentration of nitrates grow up parallel to the intensification of water flow as well. In the waters of cellar pits, unlike in those of the rivers, the concentration of the nitrate almost stays the same and it is 2-4 times lower; hence, the effect of the drainage waters in the cellar pits is insignificant, while there are more considerable factors forming the content of nitrates in the river waters, which are mostly related to the anthropogenic factors and to the fluctuation of the temperature. The increase of the nitrate content is mainly conditioned by the intensive agricultural activities implemented in the given areas, particularly in the riverine land areas, as well as, most likely, by the development of the livestock sector. As a result of the single mineral fertilization with nitrogen, some part of the nitrogen is leached and moved into the river mingling with the river waters. At the same time, some part of the cattle manure and liquid manure is imbibed into the soil and the other part is leached with the atmospheric precipitations, then gets mixed with the river waters increasing the nitrate content.

Similar pattern is observed in case of the concentration dynamics in the sulphate ion, which also grows up. Unlike in the river waters, in those of the cellar pits, the sulphate concentration practically stays the same and is 2-3 times lower. So, the recorded sulphate content in the waters of the Sotk and Masrik Rivers is formed under the influence of the Sotk mine exploitation, under the impact of pressure factors existing near the zone of the mining site along the south-eastern part of the Areguni mountain chain, as well as under the influence of the waters in the zone of the seepage flow (internal stream) of the Sotk and Masrik Rivers, particularly under the significant impact of right-bank ground and artesian (underground) waters of the catchment basin. While in the lower parts of the rivers the increase of the sulphate ion content is mainly related to the application of various agrochemicals during agricultural farming, as well as to the vaccines administered throughout cattle breeding, the residuals of which are poured into the rivers flowing through the mentioned territories increasing the amount of the mentioned ions. The most concerning issues of the environmental pollution are related to the surface waters, which come forth as a transition medium, being carriers and conveyors of the chemical elements (technogenic pollutants) (Saet and Revich, 1990). In this respect the research results conducted on the chemical composition of the investigated waters are of utmost significance and purposeful, especially when they are viewed and compared with the Maximum Permissible Concentration Limits (MPCL) determined for the studied elements in drinking and domestic waters, which are as follows: *Hg* – 0. 0005, *Cd* – 0.001, *Pb* – 0.03, *Be* – 0.0002, *Co* – 0.01, *Cu* – 1, *Zn* – 5, Cr^{+6} – 0.05, *Ni, Ba, Mn* – up to 0.1 mg/L (Yagodin, 1987, Guideline on the Chemical Analysis of Terrestrial Surface Waters, 1977, Ghalachyan and Asatryan, 2012).

The research results have indicated that the content of the chemical elements in the Sotk and Masrik Rivers is significantly low or are in line with the MPCL as to the data gained upon the investigations conducted in November, 2019 and during the previous 10 years. Besides, we'll get a more comprehensive view of the above-discussed issue, if we put forward the circumstance that within the study period the total intensity of the geochemical flow of the chemical elements in the waters of the mentioned rivers significantly fluctuates and varies depending on the exploitation of the Sotk mining site and on the changes of the mining ore volumes.

Conclusion

Summing up the conducted investigations we can draw the following main conclusions:

1. Along with the increase of the mining dimesions in the Sotk gold mine and with the increase of the amounts of rock dumps, the organoeptic and chemical indicators in the waters of the Sotk and Masrik Rivers also grow up. The quantity of the suspension particles has increased by about 210 %-317.0 % as compared to the same indices obtained for the last 10 years (2010); in the waters of the Sotk River the increase has amounted to 32.1 mg/L, while in those of the Masrik River it makes 13.2 mg/L.

2. Increasing tendencies have been also observed in the mentioned waters regarding the values in the indices of nitrate, sulphate and hydrogenic ions, which are mainly related to the chemical composition of the ore mines, where the alkaline chemicals (*Ca, K, Na, Mg,* etc.) mainly predominate, and to the intensive agricultural activities carried out in the specific areas, particularly in the riverine land areas, as well as to the application of the single nitrogenous fertilization system

and, most likely, to the development of the livestock sector.

3. The total intensity of the geochemical flow of the chemical elements into the Sotk and Masrik Rivers considerably fluctuates and varies depending on the exploitation of the Sotk mining site, changes of volumes in the ore mine and the spring river floods resulted from the snowmelt.

4. Considering the fact that the waters of the mentioned rivers are used also for the irrigation purposes and that their constituent chemical elements are endowed with great ability to accumulate in the soils (deposited), besides, their mobility is extremely reduced in the base (alkaline) medium, especially when the environmental reaction (*pH*) equals to 9, it is recommended that the managerial body of the mining industry should constantly increase the amount of lime (*CaO*) in the acidic drainage of the mining site provided that the water pH will hold up minimum within the range of 9.

Meanwhile, taking into account that individual heavy metals (tungsten, vanadium, molybdenum. etc.) are more active in the base environment, it is necessary to install filters for their refining.

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Content of Heavy Metals in the Soils of the Aragats Mountain Range

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ABSTRACT

The article considers the content and distribution patterns of heavy metals in the soils of the Aragats mountain range. The presence of heavy metals in various types of soils and migration along the soil horizons have been established based on the results of the research study. According to the content of soils, heavy metals are arranged in the following row: *Zn>Cu>Pb>Co>Mo>Cd*. The content of gross and mobile forms of heavy metals in the soils varies unevenly from top to down depending on the nature of the metals. The correlation link between the content of humus, reaction of the environment, mechanical composition of soils, gross forms of nutrients and the content of metal forms (*r=0.63±0.015 - 0.73±0.011*) has been revealed.

Introduction

Heavy metals (trace elements) play a special role in the biosphere. Existing predominantly in a scattered state, they can form local accumulations, where their concentration is hundreds and thousands of times higher than average planetary levels. Metals, being present in living organisms in negligible amounts, perform very important functions, being included as a compound of biologically active substances. The ratio of the concentrations of metals in organisms has been developed throughout the course of the evolution of the organic world (Bowen, 1979). Significant deviations from these ratios cause negative, often disastrous consequences for living organisms. Being one of the main natural resources, the main condition for the maintenance and development of modern civilization, metals form a group of the most dangerous pollutants of biosphere ecosystems. Therefore, identification of patterns (regularity) determining the content and migration of heavy metals in the biosphere, is one of the most important objectives for the protection of nature resources, including soil (Beijer, et al., 1986, Perelman, et al., 1999, Chernykh, et al., 2003, Hunanyan, et al. 2020).

Metal content in natural unpolluted soils is due to a number of factors, the main of which are the direction and intensity of soil formation process, their content in the parent rock, as well as due to the high content of heavy mineral fraction

and clay minerals, soils with heavy texture, richness in colloids and the presence of organic matters (Davtyan, et al.,1961, Mkrtchyan, et al., 2020, Perelman, et al., 2000, Sedykh, et al., 2011, Jhangiryan, 2015, Ghazaryan, et al., 2018).

It should be noted that under conditions of anthropogenic burden, the establishment of normal and toxic levels of metal content in soils is quite an urgent task.

The aim of the research is to study the heavy metal contents and their distribution throughout the soils of the Aragats mountain range.

Materials and methods

Aragats mountain range is located in the northeastern part of the Republic of Armenia at an altitude of 2000-3600 m above the sea level. The investigated territory is characterized by a cold mountain climate. The average annual air temperature is 1-3°C. Annual precipitation is 450-800 mm, which increases from bottom to top. Mount Aragats is the highest extinct volcano in Armenia (4090 m above the sea level), the lavas of which occupy a rather large area. The peak of Aragats is composed of andesite-dacites, dacites and their tuff breccias, and the slopes are covered with andesites, basalts, dacites and tuff slags (Babayan, et al., 1961, Davtyan, et al., 1961).

Mountain-meadow and meadow-steppe soils and their subtypes are widespread on the territory of the Aragats mountain range. Meadow-steppe soils are represented by two subtypes: meadow-steppe typical and meadow-steppe chernozem-like (Edilyan, 1976, Mkrtchyan, et al., 2020).

The soils of the Aragats mountain range served as a study object in this research. To study the agrochemical indicators of soils and the content of heavy metals (*HM*), stationary plots were selected at different heights and exposures, on which soil pits (profile cuts) and half-holes were laid. Analyses were carried out according to the methods generally accepted in agrochemical practice. Humus content was determined according to Tyurin method, gross nitrogen - according to Kjeldahl, phosphorus and potassium-according to Lorentz, reaction of the medium (*pH*) - with a potentiometer, the mechanical composition of soils-according to Robinson method (Arinushkina, 1970, Dospekhov, 1973).

The content of gross forms of heavy metals (HM) was determined by spectral emission, neutron activation methods (Ivanov, et al., 1979), and mobile forms - by atomic absorption method using a spectrophotometer "AAS-1" (Dueck, et al., 1984, Guidelines for the Determination of Trace Elements in Soils, Feed and Plants by the Method of Atomic Absorption Spectroscopy, 1985, Taylor, 2001).

To compare the content of HM forms, the MPC indicators (maximum permissible concentration) were taken as a basis (Chernykh, 2009, Chernikov, 2009):

Pb: gross forms - 32 mg/kg, mobile forms - 6 mg/kg,

Zn: gross forms -65 mg/kg, mobile forms -4 mg/kg,

Cu: gross forms -60 mg/kg, mobile forms-10 mg/kg,

Cd: gross forms - 2 mg/kg, mobile forms -1 mg/kg,

Mo: gross forms-10 mg/kg, mobile forms -2 mg/kg,

Co: gross forms -12 mg/kg, mobile forms-2 mg/kg.

The logarithmic function describing the change in the degree index of the heavy metal contents depending on degree variations was used as an estimating function for the studied sections (soil profiles) and the calculations were conducted using the following equation:

$$y = \log \alpha x,$$

where α is some fixed positive number, different from 1.

Results and discussions

Section 1 is located in the mountain-meadow-soddy soils at an altitude of 3171 m above the sea level on the southeastern slope of Mount Aragats, a relatively flat shield-like terrace. The vegetation is covered by a grass-forbs carpet meadow with a predominance of *Festuca ruprechtii, Campanula tridentata* and *Taraxacum stevenii*. Mountain-meadow-soddy soils are characterized by a high content of humus (organic matter) - higher in the upper layers of the soil sharply decreasing towards its depths. The reaction of the salt suspension approaches to strongly acidic (*pH* 4.1-4.4), the soil is distinguished by a light mechanical texture. The content of gross nitrogen is from 0.82 to 0.09 %, phosphorus – 0.33-0.13 % and potassium – 1.24-1.66 % (Table).

The content of gross forms of heavy metals (HM) in the soil profile is not evenly distributed, which is undoubtedly associated with the presence of humus (organic matter) and the composition of the parent rock. Thus, the content of gross copper along the soil profile ranges from 38.0 to 21.0 mg/kg, lead content - 17.2-8.6 mg/kg, zinc content – 49.0-30.2 mg/kg, cobalt – 7.6-6.6 mg/kg, molybdenum – 1.3-1.0 mg/kg, cadmium – 1.80-0.64 mg/kg. The contents of mobile forms are 5.0-2.0, 2.6-0.48, 3.9-1.6, 1.56-0.20, 0.56-0.26, 0.40-0.12 mg/kg, respectively (Figure 2).

Table. Agrochemical indicators of the soils at the Aragats mountain range*

Soil type, section №, height above the sea level	Horizon, cm	Humus, %	pH	<0.01, %	Total nutrient content, %		
					N	P_2O_5	K_2O
Mountain – meadow - soddy, 3171, № 1	0-12	20.70	4.1	25.42	0.82	0.33	1.24
	12-33	3.90	4.2	19.32	0.39	0.29	1.37
	33-60	1.50	4.4	10.94	0.09	0.13	1.66
Mountain - meadow, soddy-peaty, 3000, № 2	0-9	31.02	4.2	14.68	1.79	0.56	1.20
	9-16	11.20	4.3	23.72	1.76	0.42	1.46
	16-32	7.06	4.3	32.14	0.78	0.44	1.73
	32-43	6.15	4.4	27.86	0.41	0.50	1.20
Mountain-meadow, weakly soddy, 2800, № 3	0-15	7.9	5.3	24.75	0.75	0.42	1.06
	15-42	4.4	5.6	23.80	0.57	0.39	0.66
	42-68	2.4	5.6	23.34	0.39	0.66	1.3
	68-83	0.83	5.7	19.62	0.17	0.29	1.6
Meadow-steppe typical, 2500, №4	0-16	9.60	6.4	47.42	0.80	0.26	0.84
	16-28	6.39	6.2	31.47	0.46	0.18	0.71
	28-64	3.07	6.4	27.80	0.54	0.26	0.96

*Composed by the authors.

The correlation link between the humus content and the accumulation of HM (*r=0.63±0.015)* in the soil was identified.

Section 2 is located in the northwestern slope of Aragats mountain-meadow, soddy-peaty soils at an altitude of 3000 m above the sea level. The vegetation cover mainly contains Carex and forbs with *Taraxacum stevenii* and *Ranunculus aragazi*. In the upper horizons mountain-meadow and soddy-peaty soils are characterized by a high content of organic matters (humus), by 31.02 % sandy loamy, light and medium loamy texture, the reaction of the environment is close to weakly acidic and neutral. The amount of gross nitrogen is from 1.79 to 0.41 %, that of phosphorus - 0.56-0.42 % and potassium content - 1.73-1.20 % (Table).

The content of gross forms of heavy metals is insignificant as compared to that of in ***Section 1***, and the distribution of metals along the soil profile decreases evenly (Figure 1). The content and distribution of mobile forms of HM in the soil profile depends on the number of their gross forms (Figure 2).

Section 3 is located in mountain-meadow, weakly soddy soils at an altitude of 2800 m above the sea level, on the southern slope of Mount Aragats, with a steepness of 5-7°, a herb carpet with a predominance of *Campanula tridentata*, *Taraxacum stevenii, Carum caucasicum, Cirsium esculentu;* sometimes *Festuca ruprechtii* is also found here. The exchangeable acidity of the studied soils is quite high; in the upper horizons the humus content is much lower (7.9 %) and sharply decreases in depths. The content of gross nutrient forms (*N, P_2O_5, K_2O*) is 0.75-0.17 %, 0.66-0.29 %, 1.6-0.66 % respectively (Table). The high content of the gross forms of HM (*Cu, Pb, Co, Mo, Cd*) in the upper humus (0-15 cm) horizons is characteristic (typical) to copper, lead, zinc, cobalt, molybdenum and cadmium (Figure 1).

Section 4 is located in meadow-steppe typical soil, at an altitude of 2500 m above the sea level on the southeastern slope of Mount Aragats. Meadow-steppe typical soils are mainly characterized by medium and heavy loamy mechanical texture, high humus content (9.60 %), weakly acidic reaction medium (*pH* 6.2-6.4) (Table). Comparing to ***Section 3***, the content of gross copper is 1.02 times higher, while lead - in 1.28, zinc - 1.14, cobalt - 1.26, molybdenum -1.35, cadmium - in 1.72 times higher (Figure 1). The amount of mobile forms of the studied metals falls down with a decrease in the gross forms (Figure 2).

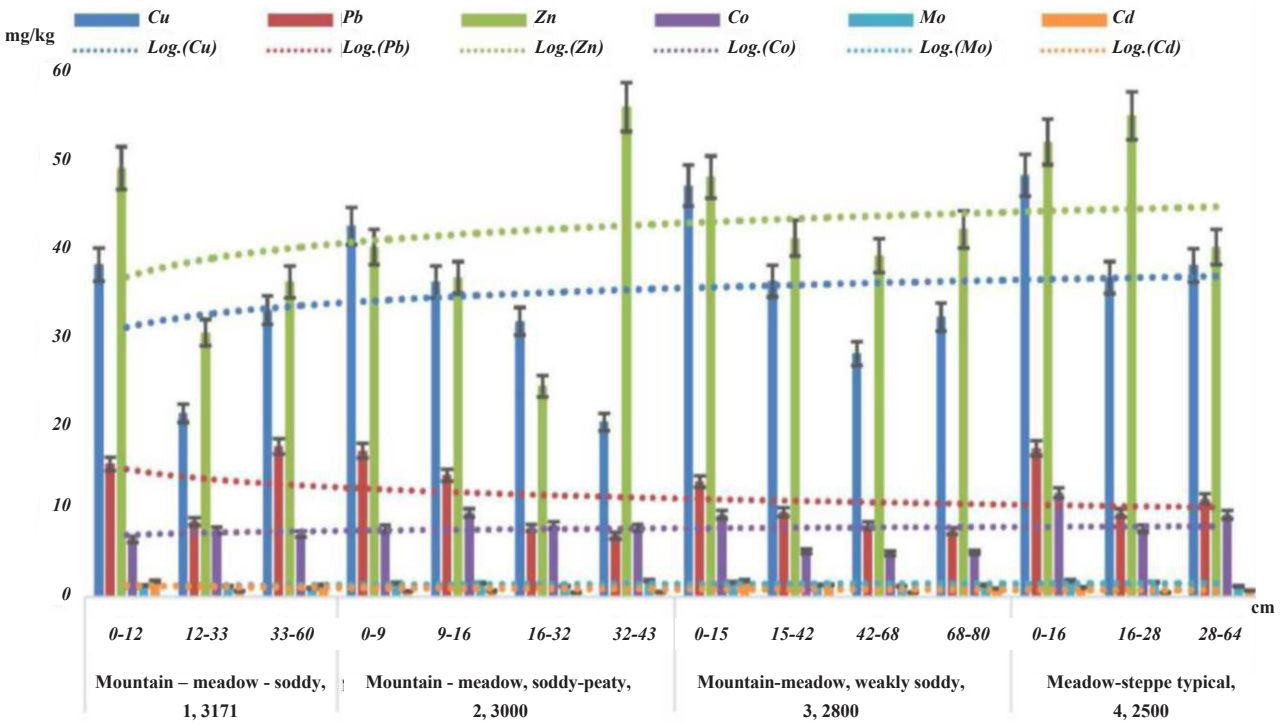

Figure 1. The content of gross forms of trace elements ((HM) mg/kg)) in the soils of the Aragats mountain range (*composed by the authors*)

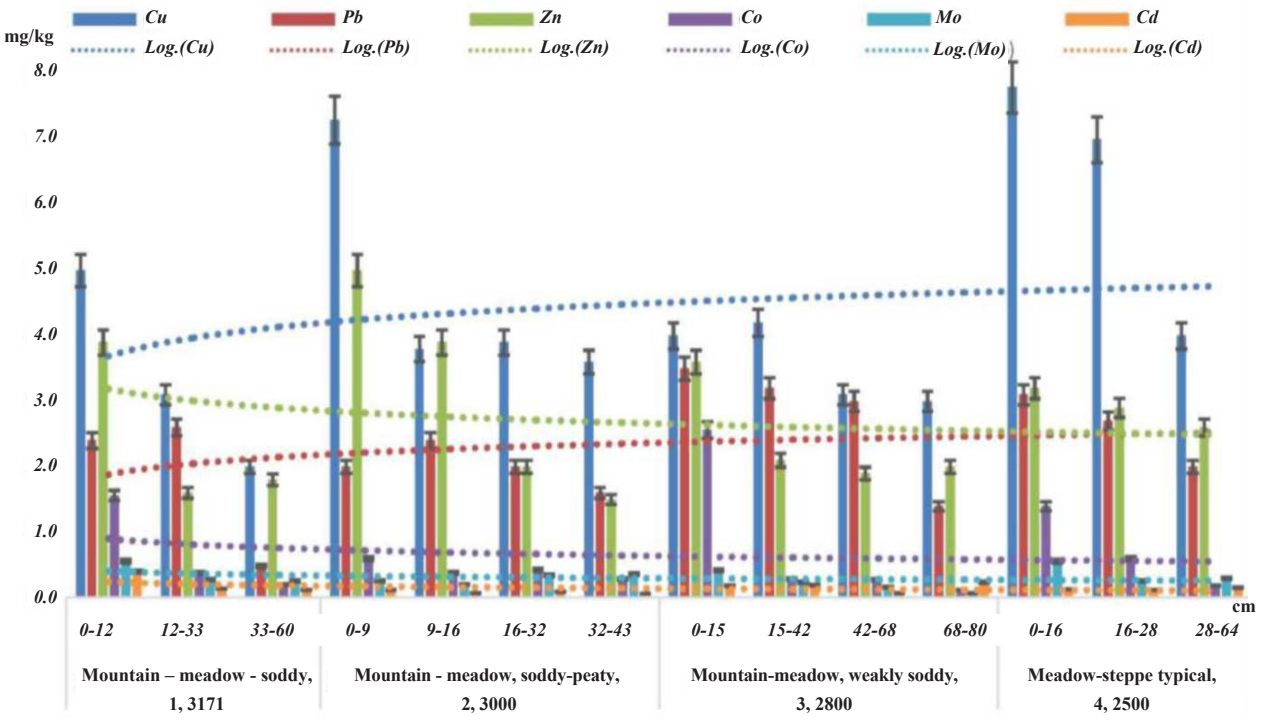

Figure 2. The content of mobile forms of trace elements ((HM) mg/kg) in the soils of the Aragats mountain range (*composed by the authors*)

There is a correlation between the content of gross and mobile forms of HM and the reaction of the environment (*r=0.73±0.011*). Correlation between the agrochemical parameters of soils and the content of HM forms (section *1-r=0.63±0.015*, section *4-r=0.73±0.011*) is typical for all studied sections.

Conclusion

Thus, based on the studies carried out, the following conclusions can be drawn:

1. The content and distribution of the forms of heavy metals in soils are mainly due to the presence of humus (organic matter), mechanical composition, reaction of the environment and the total content of nutrients.

2. According to the content of the soils of the Aragats mountain range, heavy metals are arranged in the following row: *Zn>Cu>Pb>Co>Mo>Cd.*

3. The content of gross (bulk) copper, zinc and lead increases from the top (3171 m) to down (2500 m), the amount of cadmium, molybdenum and cobalt changes uniformly/evenly.

4. The mobile forms of copper and lead are similar with the gross values. The amount of mobile zinc and cobalt decreases, and the amount of molybdenum and cadmium is evenly distributed.

5. The content of gross and mobile forms of heavy metals (*Cu, Zn, Co, Pb, Mo, Cd*) is at the MPC level.

6. The mobility of heavy metals is controlled by acid-base conditions and the amount of organic matter.

7. The bulk (basic mass) of heavy metals accumulates in the upper humus horizons (0-9 and 0-12 cm) of the soil and their content decreases towards the depth.

8. The correlation relationship between agrochemical indicators of soils and the content of heavy metal forms is *r=0.63±0.015-0.73±0.011*.

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Struggling against the Bunt and Smut Diseases of Wheat and Barley by Applying New Complex Fertilizers in the Organic Agriculture

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ABSTRACT

Cereal bunts and smuts cause a huge damage to the cereal croplands. Various fungicides are usually applied for taking struggling measures against the wheat bunt but they have very often toxic effect on humans and animals. To struggle against the smuts and bunts a complex organo-mineral fertilizer (AFM) endowed with fungicidal properties has been recommended, which is allowed to use in the organic agriculture as well.

The experimental results have disclosed that by soaking the cereal seeds with the solution of the mentioned fertilizer before the very start of sowing or even earlier, the possibility of the grain infection is prevented and economically justified yield is harvested. Thus, it is recommended to use the AFM as a means of seed disinfection.

Introduction

Cereal crop production is an important issue from the prospect of providing the safety of agri-food system in any country of the world. Along with expansion of cropland areas, cultivation of high-yieldig crop varieties, as well as introducing advanced fertilization and cultivation technologies (Gulyan, 2007, Hakobyan and Gulyan, 2007, Matevosyan and Gyulkhasyan, 2000), the implementation of efficient activities aimed at the struggle against the crop diseases is also of utmost significance for the increase of production dimensions (GOST 12044-93, FAO, UN Budapest, 2017, Laptiev, Kungurtseva, 2016, Mikhaylikova, et al., 2013). It is well known that the winter wheat and barley, as well as a number of cereal crops are more often damaged by the crop diseases of bunts, smuts and root rots (Avagyan, et al., 2017, Grigoryan and Asatryan, 1999, Mikhaylikova, et al., 2013, Pikushova, 2017, http://www.betarer.ru).

The plants diseased by the wheat bunt develop soot-like dustbags instead of ears which blast out during the harvest time and the spores are dispersed around. They can stay viable on the infected seeds in the soil for a long time. In the ears infected with cereal smut the fungal body gets transformed forming black soot-like spore mass, then they fall on the healthy flowers through the wind and germinate very quickly (http://www.betarer.ru).

There are multiple ways of struggling against the cereal bunt and smut; anyhow, the application of different fungicides (Dividend, Raxil, Polaris, Benefis, Scarlet, etc.) is currently the most widespread method. The disinfecting activities are carried out before sowing or even earlier (Avagyan, et al., 2017, Grigoryan and Asatryan, 1999, http://www.betarer.ru).

Some other scientists recommend to improve the phytosanitary conditions of the seed material in the cereal crops through the biological methods (e.g. Biocomposite-Correct), indicating that by applying the fungicides for a long time the useful microflora content of the soil medium undergoes some changes and some strains adapted to the fungicides appear in the soil or they become the reason for mutagenesis in the environment (Yevseev, et al., 2017, Yablokov, 1989). Nevertheless, this method hasn't found a widespread application.

The disadvantage of the method related to the application of fungicides against the bunt and smut diseases consists in the fact, that the active agents of the mentioned preparations have toxic impact on the humans, animals, as well as on the useful micro-organisms of the soil. Taking into account the abovementioned and considering the disinfected seed material as a harmful means for its accidental use in food products, bright colourants are mixed with disinfectants, whereupon the disinfected seeds become visible (Mikhaylikova, et al., 2013, Pikushova, 2017). Besides, such fungicides are prohibited for the use in the organic agriculture (Green Caucasus Standard. Code GC/DM/GCS-10.3).

Thus, there isn't any developed alternative method for the use of fungicides.

Materials and methods

The aim of the study is to enhance the effect of fungicidal complex fertilizer AFM (alternative fungicidal means) synthesized by our research group on the ability to prevent the infection with bunts and smuts of the winter wheat and spring barley. The effect of the mentioned fertilizer on the infectivity rate of the ears (spike) with the wheat bunt and loose smut, on the vegetation period of the plant, the structure of the yield elements, yield capacity, as well as on the grain qualitative indices has been investigated (Piskunov, 2004, Yagodin, 1987).

Field fertilization trials were conducted at the Solak community in Kotayk region, in 2016-2018 (the experimental plant - winter wheat) and at the Artik province of Shirak region in 2016-2017 (the experimental plant - spring barley). The seed grain for the field experiments was selected from the fields of the abovementioned communities, where the infectivity rate of the seeds with bunt and loose smut diseases made 1.94 %-2.35 % and 0.05 %-0.06 % respectively.

Field fertilization experiments were carried out with three repetitions and the size of an experimental material made 100 m^2 (5 m x 20 m). The winter wheat variety was Bezostaya 1, while the spring barley variety was Nutans local.

The experiments were conducted on the background of nitrogen-phosphorus-potassium ($N_{90}P_{90}K_{60}$). The double superphosphate and potassium chloride were applied during the soil preparation activities. The nitrogenous fertilizer with the dose of N_{30} was applied simultaneously with the sowing activities, the rest fertilizers were used in the plant bushing (shrubbing) period. AFM was applied prior to sowing by soaking the seeds (Tables 1-4).

During the experiments within the vegetation period phenological observations, measurements and calculations were conducted. The contamination of the ears with the wheat bunt and smut was determined through the accepted methodology (GOST 12044-93).

Results and discussions

The experiments in the Solak community were conducted on the leached black soils, where the humus content was 3.8 %, the mechanical composition was heavy clay and sandy (the physical clay - 48.4 %), and *pH* was 7.6. Out of the affordable nutrients the nitrogen content made 4.8 mg *N*, that of phosphorus - 1.8 mg P_2O_5 and potassium - 39.4 mg K_2O in100 g soil. According to the introduced data the soil type was poorly provided with nitrogen and phosphorus and well provided with potassium.

In the Artik province the experiments were conducted on simply black soils; the humus content was 4.2 %, *pH* - 7.1, the content of carbonates was 1.6 % and the physical clay made 51.6 %. As to the affordable nutrients, they were poorly provided with nitrogen (*N* - 5.7 mg), phosphorus content was very poor (P_2O_5 - 0.9 mg), while the mentioned soils were averagely provided with potassium (33.8 mg

K_2O in 100 g soil) (Melkonyan, et al., 2004, Soils of the Armenian SSR, 1976, Piskunov, 2004, Yagodin, 1987).

The results obtained from the winter wheat trials (Tables 1, 2) testify that the complex fertilizer AFM endowed with fungicidal properties has significantly promoted the seeds sprouting capacity in the field, the plant growing process, increase of the grain yield capacity, as well as the reduction of their infectivity rate with smuts and bunts of cereals.

So, according to the data of Table 1, in the control variant the sprouting capacity of the seeds infected with the mentioned diseases in natural medium has made all in all 60.0 %, while the seeds treated with the solution of AFM have demonstrated 65.8 %-75.0 % sprouting capacity. The field sprouting capacity of the seeds reached its maximum index when AFM was applied with the dose of 2.0 - 2.5 kg/ha. Similar results were recorded when Dividend was used with the dose of 2.0 kg/ha. In the variants where the seeds were treated with AFM and Dividend the height of the stems exceeded that of the control variant by 9.8 % - 13.7 %.

The data on the calculation of the number of spiciferous stems per unit area disclose that on the whole the mentioned indicator is rather low.

Table 1. The effect of AFM applied upon the fertilization background on the field sprouting capacity and plants vegetation process in the winter wheat*

Variants	The number of seeds sown per 1m², n	The number of sprouted seeds, n	Field sprouting capacity, %	Plants height, cm	The number of spiciferous shoots per 1m², n
$N_{90}P_{90}K_{60}$ background (control)	600	360	60,0	51	291
Background + AFM 1.0 kg/ha	600	395	65.8	56	345
Background +AFM 1.5 kg/ha	600	438	73.0	57	350
Background +AFM 2.0 kg/ha	600	450	75.0	58	356
Background +AFM 2.5 kg/ha	600	449	74.8	58	358
Background +Dividend 2.0 l/ha	600	448	74.7	56	355

Table 2. The effect of AFM applied upon the fertilization background on the mitigation of infection with bunt and smut diseases of the winter wheat and on its yield capacity*

Variants	The number of ears infected with wheat bunt per 1m², n	The number of ears infected with loose smut per 1m², n	The number of grains in an ear, n	The weight of the grains in an ear, g	The weight of 1000 grains, g	The yield of an ear c/ha
$N_{90}P_{90}K_{60}$ background (control)	2.30	0.08	15.3	0.60	39.2	17.6
Background + AFM 1.0 kg/ha	0.96	0.00	17.1	0.68	39.7	23.4
Background +AFM 1.5 kg/ha	0.71	0.00	18.0	0.72	40.1	25.2
Background +AFM 2.0 kg/ha	0.05	0.00	20.1	0.81	40.3	28.8
Background +AFM 2.5 kg/ha	0.02	0.00	20.0	0.81	40.5	29.0
Background +Dividend 2.0 l/ha	0.01	0.00	18.9	0.76	40.3	27.1

*Composed by the authors.

Besides, there are some differences between the variants; it is much lower in the control variant (291 n per $1m^2$), the latter is followed by the variant where AFM with 1.0 kg/ha dosage has been applied. The application of AFM with the dose of 1.5-2.5 kg/ha and that of Dividend with the dose of 2.0 kg/ha have provided equal efficiency.

The effect of AFM is obvious on the prevention of bunt and smut diseases in winter wheat and on the increase of its yield capacity. Moreover, its effect is already observed starting from the dose of 1.0 kg/ha and the final outcome is recorded in case of its administration with the dose of 2.0-2.5 kg/ha. That is, from the prospect of its efficiency the AFM dosage of 2.0-2.5 kg/ha is quite equal to 2 l/ha Dividend and thus, it can completely substitute Dividend. Besides, AFM exerts more positive effect on the plant growth and yield capacity.

This is related to the content of growth stimulants and nutrients in the fertilizer, which in their turn promote the increase of the seed sprouting capacity in the field and the further growing process of the plant; particularly, increase of the grain number in an ear, partial growth in the weight of 1000 grains are recorded, which results in higher yield capacity (Tueva, 1966, Fedotov, et al., 2006, Genkel, 1969, Chernovina, 1970). So, according to the data of Table 2, in the variant of background (control) the number of the grains in an ear makes 15.3 n, their weight is only 0.60 g, while the weight of 1000 grains – 39.2 g and the grain yield -17.6 c/ha. Whereas, in case of applying AFM on the background of $N_{90}P_{90}K_{60}$ the mentioned indicators depending on the usage dose of AFM have made 17.1-20.1 n, 0.68-0.81 g, 39.7-40.5 g, 23.4-29.0 c/ha respectively. In case of using Dividend on the background of fertilization the grain number in an ear, its weight and the weight of 1000 grains partially stay behind the same indicators observed in the best variants where the seeds have been treated with AFM. As a result, the grain yield is also rather low making 27.1 c/ha, which is less than the same index recorded in the variant of AFM (2.0-2.5 kg/ha) by 1.7-1.9 c/ha. In case of applying AFM with the dose of 1.0-1.5 kg/ha the grain yield is 1.9-3.7 c/ha lower than that of recorded in the variant where Dividend has been applied. It should be added that in those variants where AFM has been administered there is still partial effect of wheat bunt disease.

Similar efficiency has been provided in the sruggle against the bunt and smut diseases upon the use of AFM in the croplands of spring barley, which consist of common black soils located at the Artik province in the steppe zone of Armenia.

The results obtained from the experiments are summed up in Tables 3, 4. As we can see from the table data the sprouting capacity of the seeds contaminated with bunt and smut diseases in common way and further growing process of the plants, the infectivity rate with the mentioned diseases and the yield amout are greatly related to the experimented variant.

So, according to the data of Table 3, the application of complex fertilizer AFM has had a favorable effect on the field sprouting capacity and growth of spring barley. The sprouting capacity has increased by 5.8 %-13.7 %, the stems height - by 6.1 %-10.2 %, while the number of spiciferous stems per unit area has increased by 2.8 %-4.1 %.

Table 3. The effect of AFM applied upon the fertilization background on the field sprouting capacity and plant growth in spring barley*

Variants	The number of seeds sown per $1m^2$, n	The number of sprouted seeds, n	Field sprouting capacity, %	Plants height, cm	The number of spiciferous shoots per $1m^2$, n
$N_{90}P_{90}K_{60}$ background (control)	500	342	68.4	49	319
Background + AFM 1.0 kg/ha	500	362	72.4	52	328
Background +AFM 1.5 kg/ha	500	378	75.6	53	331
Background +AFM 2.0 kg/ha	500	389	77.8	53	332
Background +AFM 2.5 kg/ha	500	388	77.6	54	332
Background +Dividend 2.0 l/ha	500	367	73.4	53	330

*Composed by the authors.

The effect of AFM on the prevention of infectivity with bunt and smut diseases of the spring barley is also quite obvious (Table 4). In the control variant the number of ears infected with bunt and smut per unit area makes 1.84-1.94 and 0.02-0.05 n, while in case of using AFM with the dose of 2.0-2.5 kg/ha the infectivity rate with the mentioned diseases are completely prevented. According to the data of Table 4 the impact of Dividend on the plant growth of spring barley is lower than that of AFM, which is surely related to the availability of nutrients and growth stimulants in the complex fertilizer.

The effect of AFM on the grain number and weight in an ear of spring barley and on the increase of its yield capacity is as follows: in the best variants where AFM has been administered the number of grains against the control variant has increased by 1.1 %-19.3 %, the weight – by 1.4 %-22.5 % and the weight of thousand grains has also partially grown up (Table 4).

The impact of AFM is more observable on the yield capacity of spring barley. So, if in the control variant the grain yield has made 22.8 c/ha and in the variant, where Dividend has been applied it is 27.0 c/ha, then in the variant where AFM has been used with the dose of 2.0-2.5 kg/ha it has made 28.6-28.9 c/ha.

The effect of the complex fertilizer (AFM) on combating the bunt and smut diseases has been also experimented for the winter wheat in conditions of vegetation trials. The seed material infected with bunt and smut at the Solak community was used, which was again contaminated with the spores of bunt in laboratory conditions. The soil was taken from the experimental plots of the Solak community. The holding capacity (bulk) of vegetation vessels used for the experiments made 6.5 kg air-dry soil.

The fertilizers were introduced at the time when the vessels were filled with soil. Ammonium saltpeter, double superphosphate and potassium chloride were applied. Twenty five seeds were sown in each vessel and after their sprouting only 15 were left. During the plant vegetation period observations and calculations were carried out. Harvesting process was organized per vessels.

The results received from the experiments (Table 5) indicate that the application effect of the fertilizers, AFM and Dividend on the growth of spring barley is noticeable starting from the germination phase up to the end of vegetation priod. So, the field sprouting capacity of the seeds is much lower in the control variant making 73.6 % and it is higher in the variants of $N_2P_2K_2$ + *AFM* (0.67 %), $N_2P_2K_2$ + *AFM* (0.83 %) and $N_2P_2K_2$ + *Dividend* (1 %) - 83.6 %-86.0 %.

The application of fertilizers and AFM has promoted the plant growth as well. The height of barley plants makes only 29.6 cm in the control variant, while in the best experimental variants ($N_2P_2K_2$ + *AFM* 0.67 %, $N_2P_2K_2$ + *AFM* 0.83 % and $N_2P_2K_2$ + *Dividend* 1 %) it amounts to 38.1-40.6 cm.

The impact of AFM and Dividend on the infectivity rate of the ears with bunt and smut diseases is vivid. So, in the control and $N_2P_2K_2$ variants the number of ears infected with wheat bunt makes 3.06-3.14 n, while that of infected with loose smut is 0.06-0.07 n.

Table 4. The effect of AFM applied upon the fertilization background on the mitigation of infectivity of spring barley with bunt and smut diseases and on its yield capacity*

Variants	The number of ears infected with wheat bunt per 1m², n	The number of ears infected with loose smut per 1m², n	The number of grains in an ear, n	The weight of grains in an ear, g	The weight of 1000 grains, g	The grain yield c/ha
$N_{90}P_{90}K_{60}$ background (control)	1.94	0.05	17.6	0.71	40.4	22.8
Background + AFM 1.0 kg/ha	1.81	0.02	17.8	0.72	40.4	23.5
Background +AFM 1.5 kg/ha	0.00	0.00	18.1	0.74	40.9	24.6
Background +AFM 2.0 kg/ha	0.00	0.00	21.0	0.87	41.4	28.9
Background +AFM 2.5 kg/ha	0.00	0.00	20.8	0.86	41.4	28.6
Background +Dividend 2.0 l/ha	0.00	0.00	18.2	0.78	40.6	27.0

*Composed by the authors.

Table 5. The effect of AFM on the gowth, grain yield and infectivity rate with bunt and smut disease of the winter wheat (Vegetation experiments)*

Variants	Field sprouting capacity of seeds, %	Plants height, cm	The number of seeds infected with bunt and smut diseases in a vessel, n		In an ear		The weight of 1000 grains, g	The grain yield, g/vessel
			Wheat bunt	Loose smut	The number of grains, n	The weight of grains, g		
$N_{90}P_{90}K_{60}$ background (control)	73.6	29.6	3.06	0.07	12.8	0.44	34.6	6.80
Background + AFM 1.0 kg/ha	74.0	37.4	3.14	0.06	15.3	0.57	37.3	8.98
Background +AFM 1.5 kg/ha	75.8	38.1	2.94	0.05	15.6	0.59	37.7	9.38
Background +AFM 2.0 kg/ha	83.6	40.4	0.04	0.00	18.6	0.76	40.8	12.42
Background +AFM 2.5 kg/ha	85.1	40.6	0.00	0.00	18.7	0.77	40.9	12.71
Background +Dividend 2.0 l/ha	86.0	38.6	0.00	0.00	18.3	0.72	36.5	11.77

*Composed by the authors.

Some bunt-stricken ears have been also observed when 0.5 % of AFM solution has been applied on the background of $N_2P_2K_2$. Whereas, when the seeds were soaked with 0.67 %-0.83 % AFM solution prior to sowing, no infected ears were recorded at all.

The favorable effect of AFM and Dividend on the barley growth and yield capacity has been manifested through the increase of grain number in an ear, weight of 1000 grains and grain yield. Thus, the grain yield in the contol variant has made 6.8 g/vessel, in $N_2P_2K_2$ variant it is 8.98 g/vessel, while in the variants of $N_2P_2K_2$ + *AFM* (0.67 %) and $N_2P_2K_2$ + *AFM* (0.83 %) it makes 12.42-12.71 g/vessel. The high yield in the mentioned variants is related to the macro- and micro-elements promoting the plant growth, as well as to the content of growth stimulants, which in their turn result in high yield production.

Conclusion

Wheat bunt and loose smut diseases are rather widespread not only throughout Armenia, but also in the cereal croplands of other countries causing huge amount of damage to the plant growing process and yield capacity.

Different fungicides are usually applied in the struggle against the mentioned diseases. Anyhow, they have toxic effect on humans, animals and useful soil-dwelling micro-organisms. They are also prohibited for the use in the organic agriculture.

A complex fungicidal organo-mineral fertilizer has been recommended by our research group to struggle against the diseases, namely alternative fungicidal means. It is manufactured through the processing of biogen diatomite rocks from the Sisian province and contains silicium, aluminum, calcium, magnesium, phosphorus and iron which is enriched with additional amount of macro- and micro-elements and humus materials. This fertilizer is allowed for the use in the organic agriculture.

The experiments have shown that by soaking the seeds of winter wheat and spring barley, including those infected with bunt and smut diseases, with the solution of AFM prior to sowing process or even earlier, their infectivity rate with the mentioned diseases is somehow prevented.

Standard amount for AFM application has been identified, according to which the seeds should be soaked with up to 97.8 %-100 % AFM solution, whereby the infection of winter wheat and spring barley ears with bunt and smut diseases can be prevented. Such effect for Dividend is observed in case of applying 99.6 %-100 % solution, nevertheless, AFM surpasses Dividend in terms of its impact on grain number in an ear (by 5.5 %-6.0 %), weight (by 6.6 %) and yield capacity (by 6.3-7.0 %).

Based on the experimental results it is recommended to use AFM for the struggle against the bunt and smut diseases

in the croplands of winter wheat and spring barley. The standard dose of the mentioned fertilizer makes 1.5-2.0 kg for 300-320 kg seed material.

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Novel Potential Feed Probiotics for Fish: *Lactobacillus rhamnosus Vahe*

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ABSTRACT

The article considers the possible role of lactobacilli probiotics in protection of salmon against fish pathogens. The aim of this work is to study the viability of the potential probiotic *Lactobacillus rhamnosus Vahe* immobilized in salmon feed. Lactobacilli strains of human origin might have good probiotic efficacy in animals, including fish. According to this study, a decrease in viability (from 100 % to 78.00 ± 3.14 %) of the probiotic in feed biofilms was detected over a 2-month period. A simple procedure has been recommended that ensures viability of probiotics and can be applied for the evaluation of probiotic candidates in the future.

Introduction

The main trend in the development of aquaculture in Armenia is pond fish farming. Its effectiveness largely depends on the quality and quantity of used feed. Reduction of feed cost is one of the main economic factors, which can increase the profitability of fish farming. Probiotics used in the fish feed significantly influence feed consumption per unit of fish growth, since they increase the rate of feed assimilation, neutralize mycotoxins, displace pathogenic microflora and strengthen the general resistance of fish (Mitropoulou, et al., 2013, Ridha and Azad, 2016, Van Doan, et al., 2018). Therefore, probiotics come forth as an alternative for disease prophylaxis and treatment, particularly from the prospect of emerging antibiotic resistance in aquatic environments (Carvalho and Santos, 2016, O'Flaherty and Cummins, 2017) and in aquacultural sites (Smith, 2008, Suzuki, et al., 2017). Lactobacilli probiotics might colonize the fish-gut and also fight against gram-negative fish/human pathogens in fish tanks (Ring and Gatesoupe, 1998, Munoz-Atienza, et al., 2013).

The aim of the current study is the investigation of viability of the potential probiotic *Lactobacillus rhamnosus Vahe* in immobilized salmon feed, demonstrating high antagonistic activity against several multi-resistant hospital pathogenic isolates of *Acinetobacter baumanii, Enterobacter gergoviae, Klebsiella pneumonae* and *Staphylococcus*

aureus, and possibly against other fish bacterial pathogens belonging to *Edwardsiella* and *Pseudomonas* species.

Materials and methods

Probiotic strain *L. rhamnosus Vahe* isolated from the feces of the healthy infant was used in this study (Pepoyan, et al., 2018b, Pepoyan, et al., 2020, Balayan, et al., 2019). Bacterial strains were cultured in De Man, Rogosa and Sharpe (MRS) broth and on MRS agar (Thermo Scientific™, UK). When required, Oxoid™ Endo Agar (Thermo Scientific™, UK) and VITEK® 2 compact (BioMerieux, France) were used for the identification of bacterial cells (Holt, et al., 1994).

To obtain the biofilms and to assess the viability of the bacterial cells, the bacteria were grown for 24 hours in MRS medium, then the fish feed granules (Nuti 0, ALLER PERFORMA) were added to the bacterial suspension, left for 1 hour, and then transferred to sterile saline and stored in a refrigerator at 2-8 ^{0}C. For viability analyses 100 mg of obtained probiotic supplement was added to 0.3 ml saline, mixed, left for 2-3 minutes and then 0.1 ml of the suspension was transferred on MRS agar; viability was checked 24 hours after incubation at 37 ^{0}C. The viability of the bacteria was assessed on the 5th, 10th, 20th, 30th, 40th, 50th and 60th days.

To investigate the changes in antibacterial activities of the probiotic strain after immobilization, a colony of *K. pneumonae* was dissolved in 1 ml of MRS, then 0.1 ml of the mixture was added to 0.9 ml of MRS as a *K. pneumoniae* control, and 0.1 ml was added to 0.9 ml of MRS containing 0.1 ml of probiotic suspension. A suspension of probiotics was prepared in the following way: 3 feed pellets with probiotic biofilms were added to 0.3 ml of saline solution, mixed for 10-15 seconds and 0.1 ml of supernatant was used for the experiment. To compare the anti-*Edwardsiella* activity, the probiotic on the feed granules was added to 10 ml of the tank water containing 104 CFU/ml *Edwardsiella* sp. The titer of bacteria was compared with its control suspension without feed granules after 2 days of incubation at 22-25 ^{0}C.

Results and discussions

Probiotics can be selected based on the production of antimicrobial compounds such as bacteriocins, siderophores, or the presence of competition for nutrients. In addition, such properties as antioxidant and antimutagenic activity, and the ability to form biofilms are important for the host organism.

In the framework of previous studies we characterized probiotic strain *L. rhamnosus* Vahe with antagonistic activity against *A. baumannii*, *S. aureus, K. pneumoniae* and Enterobacter gergoviae (Pepoyan, et al., 2018 b). The radioprotective ability, biofilm forming ability, cell surface hydrophobicity and the effectiveness of using the probiotic strain were demonstrated. In addition, preliminary studies have disclosed the possibility to use the strain for aquaculture (Pepoyan, et al., 2018 a, b).

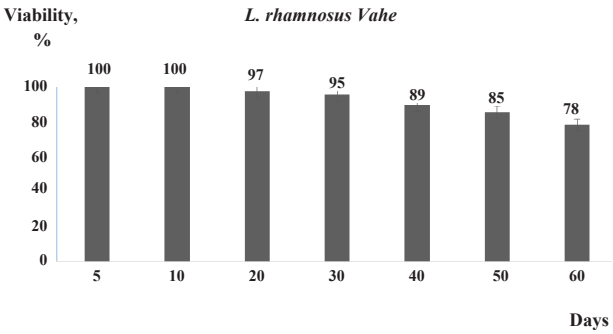

Figure 1. The viability of *L. rhamnosus Vahe* in probiotic feed granules during 2-month storage (*composed by the authors*).

For successful application of probiotic strains as microbial ingredients for fish, other characteristics seem to be essential, such as high viability during processing, throughout storage and after gastro-intestinal transit. Figure 1 relates to changes in viability of *L. rhamnosus Vahe* in probiotic fish feed granules during 2-month storage. These investigations showed that non-lyophilized cells of *L. rhamnosus Vahe* remain viable for a long time (Figure 1). A decrease in bacterial titer was recorded only after 20 days of storage, and the rate of the decrease was very slow. According to this study, a decrease in viability (from 100 % to 78.00 ± 3.14 %) of the probiotic in feed biofilms was detected over a 2-month period.

The antagonistic potential of the biofilm forming strain against *K. pneumoniae* was also investigated. The study showed that the biofilm forming strain is able to maintain antagonistic potential against the pathogen during 60 days of storage. It is shown that the number of the pathogenic cells has sharply dropped when the pathogen is grown together with the probiotic strain. The results (Figure 2) show that the titer of *Klebsiella* cells after incubation with

the probiotic is only 2 × 104 CFU/ml, while in the control tube, the titer of *Klebsiella* reaches 4 × 1011 CFU/ml.

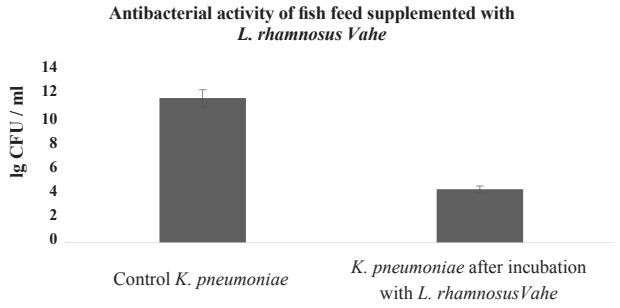

Figure 2. The effect of *L. rhamnosus Vahe* on *K. pneumoniae* cells (*composed by the authors*).

The preliminary study of the effect of probiotic feed on 104 CFU/ml of *Edwardsiella sp.* in tank water showed a suppression of pathogenic bacteria, in contrast to the identified positive effect of feed alone on the viability of *Edwardsiella spp*.

Several demanding strategies such as micro- and bio-encapsulation of the probiotics have been described (Martínez, et al., 2012, Rosas-Ledesma, et al., 2012); we have also presented a simple and cost-effective method that affected only the integrity of the pellets to an acceptable degree.

When supplementing experimental diets with probiotics the need arises to up-scale cell cultivation. The experimental evaluation confirms that expensive and complex probiotic administration processes using technologies such as drum or vacuum coating systems are not required to ensure the high survival rate of the probiotic during preparation and long-term storage. After almost eight weeks of the storage, the viable colony forming units did not decrease even by a tenth power. It is important that bacterial cells should be harvested at the end of the logarithmic growth phase, because a delayed harvesting could cause a self-inhibition of bacteria or the production of unwanted secondary metabolites.

Conclusion

It has been found out that fish feed supplemented with probiotic *L. rhamnosus Vahe* could be stored at 4 ^{0}C for 60 days, without a major decrease in the viability of the probiotic cells. The study of the antagonistic potential of the biofilm forming *L. rhamnosus Vahe* strain showed that the probiotic strain is able to maintain antagonistic potential against *K. pneumoniae* during 60 days of storage and suppress the growth of *Edwardsiella sp.* in tank water.

Thus, the recommended simple immobilization procedure of biofilm forming probiotic cells on the surfaces of feed granules assures viability of the probiotic and can be applied for the evaluation of probiotic candidates in the future.

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Microbiological Contamination of Eggs in the Shopping Centers of Nor Nork Administrative District in Yerevan

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ABSTRACT

Bacteria belonging to the genus Staphylococcus and Salmonella are released as conditional causative agents, which can lead to the development of an infectious process with reduced general resistance of the human body.

Egg surfaces of all the studied groups are infected with bacteria of the genus Staphylococcus, while the surfaces of the eggs in the 3rd group and factory eggs are infected with Salmonella. Studies confirm that before using eggs, it is necessary to wash them, especially when preparing fried eggs or soft-boiled eggs, since in these cases the yolk isn't subjected to full thermal treatment. So, bacteria from outside can easily penetrate into the egg when breaking its shell.

Introduction

The role of eggs in the human diet is indispensable. It is known that in average a person consumes about 200 eggs per year. Well-assimilated egg protein promotes muscle growth in the human body, strengthens bones, maintains tissue integrity, stimulates functional activity of the brain, and prevents the development of hypertension. Egg white contains alpha-amino acids that have high antioxidant activity and suppress the growth of cancer cells. One of the most valuable amino acids in egg white is lecithin, which prevents vascular thrombosis and the development of dystrophic processes in the liver. Egg yolk also contains a number of nutrients for the human body: omega-3 fatty acids, vitamins *A, K, E, B12*, selenium, calcium and phosphorus (GOST 26670-91). At the same time, the eggs can be contaminated with pathogenic bacteria, causing toxicosis or toxic infections in consumers, if the necessary sanitary rules are not observed during storage and transportation. Studies have shown that high humidity promotes the growth of bacteria and fungi on the surface of an eggshell and their subsequent penetration into the egg. Infected eggs with pathogenic bacteria, most often lead to salmonellosis or staphylococcal toxicosis (Baydevlyatov, et al., 1980). Dietary eggs should be clean, intact, without traces of blood or bird droppings. Salmonella is an acute intestinal infectious disease of humans, animals and birds. There are over 2500 salmonella serotypes (https://www.who.int, 2018). Salmonellosis is widespread throughout the world. The main source of infection is sick animals and birds, as well as people's poor compliance with hygiene rules.

Pathogens are excreted from the body of birds through faeces, vomiting and urine. In this case, it is likely that we will find salmonella and staphylococci on fresh farm eggs. The number of pathogens is important for infection, but children can be infected even from a small number of pathogens. One can be infected via food (meat, meat products, fish, milk and dairy products, egg and egg powder), as well as via contact (dirty hands, various objects, dust, especially in children's institutions, hospitals, sanatoriums, maternity hospitals). The hidden period of salmonellosis lasts from a couple of hours to 2-3 days. The disease begins acutely. The main symptoms are vomiting, severe nausea, chills, fever, headache, abdominal and muscle pain, often accompanied by diarrhea, severe dehydration and severe intoxication (Slyusarenko, 1984). The clinical picture of salmonellosis is very diverse. After recovering, the parasite lives from few weeks to 6-8 years.

The treatment can be organized through gastric washing, consumption of a large amount of warm liquid, in severe cases, administration of saline solutions, spasmolytics, antibiotics and diet. It is always easier to prevent than to cure, so prevention is important and it can be realized through the following activities:

- Veterinary sanitary control, compliance with sanitary regulations at slaughterhouses, processing, storage, transportation of food products,
- Application of personal hygiene rules in food institutions, children's institutions and households.

As to staphylococci, they are present almost everywhere. The most dangerous of them are golden staphylococci. Staphylococcus lives in intestines, genitals and airways. If placed in the intestine, external symptoms may not appear until the body's immunity decreases. This may lead to diarrhea, purulent skin inflammation, pneumonia and intestinal infections.

Staphylococcus itself is not as dangerous to the body as toxins caused by its biological activity, which can cause severe poisoning and severe pain in humans (Kuzmin, Sefershaev, 1959). Diseases that can occur through staphylococcus infection are pneumonia, osteomyelitis, angina, laryngitis, stomatitis and other respiratory diseases, as well as meningitis.

Bacteria belonging to the genera Staphylococcus and Salmonella are known to exhibit themselves as a conditional pathogen, which can lead to the development of an infectious process with reduced general resistance of a human body.

Our goal was to study the bacterial contamination of eggs sold in the stores of Nor Nork administrative district with microorganisms of the mentioned species. The eggs were bought in the Yerevan City supermarket, in the market of the 2nd microdistrict at Nor Nork, as well as from individuals in the surrounding areas.

We were faced with the following tasks:

1. Identifying surface contamination of eggs sold at Nor Nork administrative district
2. Determining the degree of bacteriological contamination of the egg surfaces
3. Making a comparative study of eggs purchased from individuals and purchased in the market and supermarket
4. Developing regulations to avoid possible toxic infections.

Materials and methods

Various nutrient media have been used for the study, in particular Bismuth sulfite agar, Mannitol salt agar, laboratory utensils, Petri dishes, dyes - crystal violet, iodine, Gram decolorizer, safranin, chemicals, filter paper, disinfectants, syringes, as well as equipment including an autoclave, thermostat, refrigerator, water distillation apparatus, microscope, etc. We used farm chicken eggs, factory eggs of different sizes (50-65 g) and quail eggs.

We purchased nine samples of farm chicken eggs sold by different people and divided them into 3 groups (1, 2, 3). Also, we purchased three samples of quail eggs and three samples of factory eggs, which were purchased from one store and divided into two groups - chicken eggs (factory, one manufacturer) and quail eggs. Washing all eggs separately with 1 ml sterile saline, we took 1 ml from the total washing solution of each group, diluted it with 9 ml sterile saline. Then 0.5 ml of each group was taken from the obtained solution by sowing on Mannitol salt agar to isolate staphylococci and on Bismuth sulfite agar to differentiate salmonella (GOST 26670-91). The medium was placed in a thermostat at 37^0C for 48 hours (Baron, 1982). The total amount of bacteria in 1 milliliter of the test solution was determined by the following formula:

$$X = an/(cv),$$

where X is the number of bacteria in 1 milliliter (gram) of the test sample, a is the average number of colonies in the nutrient medium, n is the dilution rate of the test substance, c is the test sample amount (g (ml)), v is the volume of material (solution) taken for sowing.

The size of the bacteria was determined using a micrometer

ruler. In coccus, the diameter was determined, and in salmonella we determined the length and width expressed in micrometers.

Results and discussions

Thus, colonies of staphylococci with white, straight edges were found in all groups growing on Mannitol salt agar, and salmonella was found on Bismuth sulfite agar in household eggs belonging to the 3rd group and on eggs of the factory group. Gram-stained microbiological preparations prepared from cultures were microscopically examined. As a result of microbiological studies, colonies of gram positive staphylococci were found under a microscope in the form of grape-like clusters with a diameter of 0.6 to 1.2 μm, whereas, in the samples of household eggs belonging to group 3 and in factory eggs up to 7 μm long, 0.7 μm wide, gram-negative, single or bunched salmonella were found. In addition to the above-mentioned bacteria, all bacterial preparations subjected to microscopic examination contained fungi and fragments of micelles. The presence of fungi and staphylococcus in samples taken from the surfaces of eggs of all groups indicates non-compliance with sanitary standards during the storage, transportation and sale of eggs.

However, samples of eggs 3 and factory groups indicate the presence of salmonella in laying hens on farms producing these eggs. The presence of salmonella-carrying birds on poultry farms poses a danger not only to maintenance personnel, but also to poultry farms on the whole, which suffer huge losses due to the fall of chickens and a decrease in eggs in infected chickens. Therefore, in order to ensure the safety of birds from salmonellosis, a complex of anti-salmonella measures must be carried out on poultry farms, which includes mass diagnostic, veterinary and sanitary measures, disinfection of poultry farms and incubators, treatment of sick birds and, of course, detection of infected birds.

Conclusion

According to the results of the study, the following conclusions can be drawn:

1. The surfaces of the eggs belonging to all groups studied are infected with the bacteria of the Micrococcaceae family, the genus Staphylococcus, and the surfaces of the eggs of the factory and 3rd group are infected with bacteria of the Enterobacteriaceae family, the genus Salmonella.

2. The average arithmetic number of staphylococci and salmonella of washed egg is accordingly 2.728 and 280 colony forming units which indicates high contamination rate in the eggs purchased by Nor Nork administrative district.

3. Considering that staphylococcal and fungal infection of eggs is associated with violation of sanitary standards during the storage, transportation and sale of this product, it is recommended to purchase products stored in refrigerators, packed in clean containers, without traces of blood and bird droppings on the external surface.

4. Eggs intended for food should be washed under running water immediately before consumption, which will prevent the penetration of pathogenic and conditionally pathogenic bacteria into the soft-boiled or lightly fried eggs.

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Bioconcentration of DDT and its Isomers in Carrots Grown in the Rural Community of Aramus in the Kotayk Region of Armenia

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ABSTRACT

In soil and carrot samples collected in the frame of this research from the same carrot beds in the rural community of Aramus, residual DDT and its isomers p,p′-DDT, p,p′-DDD, o,p′-DDT and p,p′-DDE were detected. In all soil samples, the total concentration of DDT exceeded maximum allowable concentration (MAC). In carrot samples, three isomers out of four were detected: p,p′-DDT, o,p′-DDT and p,p′-DDE, the total concentrations of which did not exceed MAC. The DDT/DDE ratio has indicated that the detected concentrations of DDT are due to historical usage of these pesticides. The bioconcentration factor (BCF) values vary in the range of 0.02-0.37.

Introduction

Residues of organochlorine pesticides (OCPs) and particularly dichlorodiphenyltrichloroethane or DDT, and its isomers are most commonly found in the environment since they came into wide use in pest control and for combating the disease pathogens in domestic animals and humans from the last half of XX century (Kafilzadeh, 2015). Despite their effectiveness, DDT and its isomers do rank among Persistent Organic Pollutants (POPs) (Commission of the European Communities, 2007) as these pesticides can persist in soils for a long time and when migrating in the environment, they accumulate in living organisms and finally enter food chains (Okoffo, et al., 2016). Being a hydrophobic organic compound, DDT has high affinity to soil organic matter, that causes this chemical to accumulate in organic-rich upper humic soil horizons (Li, et al., 2018). Due to its lipophilicity, DDT accumulates in animal and human tissues (Kafilzadeh, 2015) and as a consequence often provokes intoxication. This chemical as such does not cause specific diseases, instead, it depresses the immune system, the mechanism of which has been studied insufficiently so far. The main targets for DDT to affect are the reproductive organs and liver (Jallow, et al., 2017, EFSA, 2006), besides, this compound ranks among potential carcinogens for humans (IARC, 2015).

Residual DDT is detected in both animal-based food (milk, meat, fat, fish, etc.) (Kotinagu & Krishnaiah, 2015, Liu, et al., 2010) and fruits and vegetables (Chourasiya, et al., 2014). Out of vegetables, this chemical is most frequently found in root and tuber crops (carrot and beet roots, potato, etc.) due to their immediate contact with soil

(Mikes, 2009). Both absorption and accumulation of DDT are mainly influenced by three factors: 1 - crop species, 2 - presence and concentration of DDT in soils and the aging time of its application and 3 - soil quality, e.g. the content of organic matter and agricultural conditions, the irrigation system (Li, et al., 2018). Hence, it is important to conduct monitoring to identify OCPs in the environment and assess their migration- and bioaccumulation-associated risks.

Armenia ranks among states, who used large quantities of DDT as insecticide (Sargsyan V. & Sargsyan A., 2006). Taking into consideration ecological issues associated with the usage of OCPs, in 2001 Armenia joined the Stockholm Convention and in 2003 ratified it undertaking to ban OCPs including DDT (UNEP, 2017). It should be stressed that information about OCPs emphasizing pesticides in Armenia's agricultural soils and crops is incomplete and consequently no relevant risk assessment has ever been done in the country. To address the gaps, the Center for Ecological-Noosphere Studies (CENS) NAS RA implemented a state target program "Monitoring residual pesticides in foods produced in the Republic of Armenia" (2014-2018). The Program was designed to determine residual pesticides in soils, irrigation water and locally grown fruits and vegetables in the largest rural communities - fruit and vegetable producers - located in the marzes of the country.

In this particular research the data of aforesaid state program (Hovhannisyan, et al., 2018; Tepanosyan, et al., 2019) was used and it was done in the frame of base financing program of CENS NAS RA with a purpose to calculate the coefficient of DDT bioconcentration in carrot roots.

Materials and methods

The carrot bed soils and carrot roots were sampled on a random basis, in 2017 in rural community of Aramus located in Kotayk region following SOPs developed by the research group in compliance with ISO (ISO, 1980, 2002a), US EPA (US EPA, 1999) standards and FAO Guidance on Sampling Methodology (FAO, 2009). In total, 7 soil and 7 carrot samples were collected. Each composite soil sample was composed of 8-10 sub-samples, while composite carrot samples consisted of 12 carrot roots each. The samples were all placed into plastic packages and transported at 4 ^{0}C to the Central Analytical Laboratory CENS (accredited by ISO: 17025) to be then analyzed for residual DDT. The following isomers were detected and quantified: o,p′- DDT, p,p′- DDT, o,p′- DDE, p,p′- DDE, o,p′- DDD, p,p′- DDD.

Prior to lab measurements, the samples underwent pretreatment as follows: soil samples were dried, sieved (<2mm) and then pounded in an agate mortar consistent with ISO 11464 (ISO, 2006). The carrot samples for a complete cleanup were thoroughly washed by tap water, rinsed by deionized water and then dried on filter papers.

The subsequent extraction and cleanup of the pretreated soil samples was done by a microwave extractor (Start E, Milestone, Italy) in the acetone-hexane solution (1:1) with the following program: Pace 1-10 min., 1000 W, 120 ^{0}C, Pace 2-20 min., 1000 W, 120 ^{0}C. Then the sample containers were cooled to a room temperature, and the solutions were filtered (ASTM D6010-12) (Tepanosyan, et al., 2019).

The extraction of the shredded carrot samples was done in a separating funnel with sodium chloride solutions, sulfuric acid and distilled water (EN 12393-2:2008). The filtrates were then refined by column chromatography with silica gel. The eluate derived was concentrated to 2 mL with a rotary evaporator. The solution derived was then used for residual DDT to determine by a gas chromatography technique.

To determine residual DDT and its isomers in soil and carrot samples, a Trace GC Ultra gas chromatograph (Thermo Electron Corporation, USA) equipped with an automated injector (Combi PAL; CTC Analytics AG, Switzerland) and a mass spectrometric detector (Trace DSQ; Thermo Electron Corporation, USA) was employed. As carrier gas helium was used (1mL/min). For the quality of analytical work to assess, standard solutions of DDT and its isomers were prepared based on AccuStandard ISO 6468-PEST standards (New Haven, USA) (Hovhannisyan, et al., 2018).

The sensitivity of the method was evaluated based on the Limit of Quantification (LOQ) and Limit of Detection (LOD) which made 0.0006 mg/kg and 0.00006 mg/kg, respectively, whereas Relative Standard Deviation (RSD %) was varying from 1.1 % to 3.5 % (Tepanosyan, et al., 2019).

The level of DDT and its isomers bioaccumulation in the carrot was determined by formula (Li, et al., 2018) in the following way:

$$BCF=Cp/Cs,$$

where *BCF* is the bioconcentration factor, *Cp* – the concentration of a pesticide in a plant; *Cs* – the concentration of a pesticide in soils.

The statistical analysis of data obtained was done based on the Microsoft Excel (MS Office 2016) program.

Results and discussions

The results of lab analyses have indicated that 14 soil and carrot samples all contain at least a single DDT isomer (Hovhannisyan, et al., 2018, Tepanosyan, et al., 2019). This can unambiguously be explained by the fact of deposition of the given pesticide in agricultural soils (Jallow, et al., 2017) because as early as several decades ago this chemical was used in enormous quantities nationwide (Sargsyan V., Sargsyan A., 2006). According to literature sources, residual OCPs in soils can be absorbed by plants emphasizing root and tuber crops which sit immediately in the soil (Mikes, et al., 2009). Due to osmotic pressure, residual pesticides travel from soil to plants and accumulate in their vegetative organs (Wang, 2011).

In all soil samples residual ∑*DDT* exceeded the maximum allowable concentration (MAC) 0.1 mg/kg in soils. The most frequently detected isomers included *p,p'-DDT, p,p'-DDE* and *o,p'-DDT*, whereas *p,p'-DDD* was only detected in a single sample (Tepanosyan, et al., 2019). The coefficient of variation (*Cv*) for isomers made 26 - 73.2 %, for ∑*DDT - 32.0 %* (Table 1).

The samples of carrot - as distinct from those of soils - contained the residues of three isomers namely *p,p'-DDT, o,p'-DDT, p,p'-DDE* (Hovhannisyan, et al., 2018). For all carrot samples, ∑*DDT* did not exceed *MAC* and *MRL* for carrot-0.1 mg/kg and 0.05 mg/kg respectively established by the EEC and EC, but for a single sample, which showed insignificant excess of residual ∑*DDT* against *EC MRL* alone. In this case, the coefficient of variation (*Cv*) for *DDT* isomers varied 49.2 to 62.7 %, amounting to 78.5 % for ∑*DDT* (Table 2).

The data obtained suggest that ∑*DDT* concentrations in soils are far higher than those in carrot. An explanation is that the organic matter sorption ability of plants is too limited, so, the higher the concentration of soil organic matter, the higher the concentration of a contaminant in roots and tubers (Trapp & Legind, 2011).

Table 1. The detected residual DDT and its isomers in the soil samples (n=7)***

Isomers	Detection frequency, %	Average value, mg/kg	Standard Deviation, (SD)	Coefficient of variation, (Cv), %	Range, mg/kg
p,p'-DDT	100	0.047	±0.026	54.2	0.02 - 0.093
p,p'-DDD	14.3	-*	±0.007	-	n/d** - 0.017
o,p'-DDT	85.7	0.018	±0.013	73.2	0.007 - 0.041
p,p'-DDE	100	0.293	±0.076	26.0	0.191 - 0.413
∑*DDT*	100	0.358	±0.114	32.0	0.218 - 0.565

Note: **- no data, ** n/d – not detected.*

*** Tepanosyan, et al., 2019.

Table 2. The detected residual DDT and its isomers in carrot root samples (n=7)*

Isomers	Detection frequency, %	Average value, mg/kg	Standard Deviation, (SD)	Coefficient of variation, (Cv), %	Range, mg/kg
p,p'-DDT	57.1	0.00096	±0.00056	58.1	0.00062 - 0.00132
o,p'-DDT	28.7	0.014	±0.007	49.2	0.013 - 0.016
p,p'-DDE	100	0.018	±0.011	62.7	0.007 - 0.042
∑ *DDT*	100	0.023	±0.018	78.5	0.007 - 0.058

*Hovhannisyan, et al., 2018.

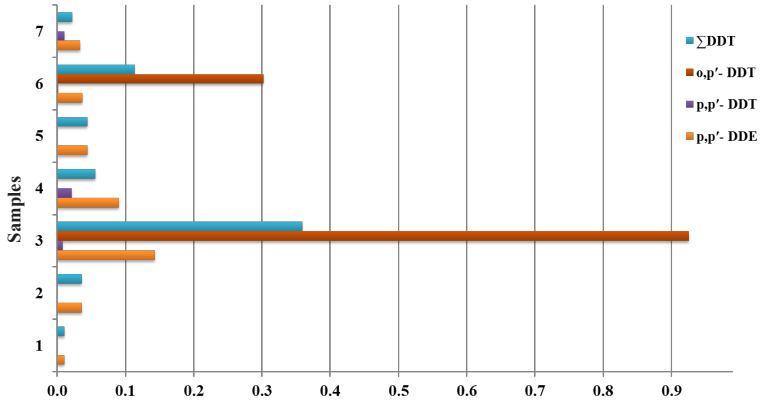

Figure 1. The coefficient of bioaccumulation for ∑DDT and individual isomers in the sampled carrot (*composed by the author*).

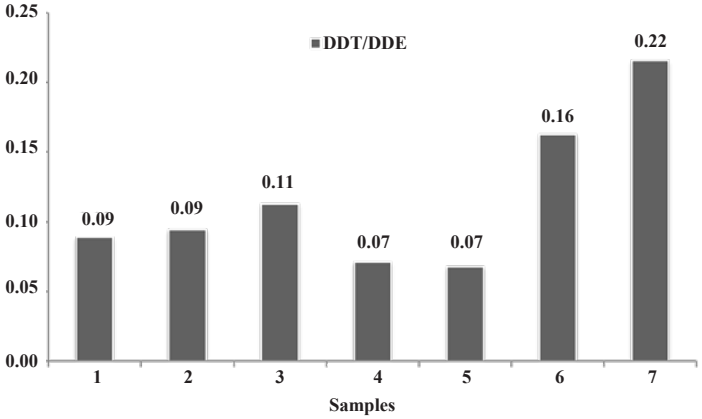

Figure 2. The DDT/DDE correlation in soil samples (*composed by the author*).

Calculation of the *BCF* allows predicting the level of bioaccumulation of organic matter by different organisms (Gao, et al., 2005). *BCF* ∑*DDT* varied 0.02 to 0.37 given the standard deviation ±0.12 and on the average made 0.10. The bioconcentration data are given in Figure 1.

The indices obtained were lower than those reported by Gao H. J., et al., 2005 where mean *BCF of* ∑*DDT* in carrot was 0.80.

Different researches (Gao, et al., 2005, Tao, et al, 2008) suggest that the ratio of concentrations of *DDT* isomers in soils is indicative of the time of the application of this chemical on the given site. To define *DDT* application timescales in Aramus community, a calculation was made in the correlation of *DDT/DDE* concentrations in the sampled soil, too. According to some researchers (Gao, et al., 2005), should *DDT/DDE* correlation be >1, it is indicative of a recent introduction of *DDT*.

For all samples, this correlation is below 1, this being indicative of a historical application of *DDT* on the studied site (Figure 2).

Conclusion

Conclusions derived from this particular research are as follows: the residual *DDT* in soils sampled from carrot beds across the rural community of Aramus exceeded *MAC* several tens of times. The ratio *DDT/DDE* showed the historical usage of this pesticide in that territory. Meanwhile, the residual *DDT* in the sampled carrot roots did not exceed the national MAC, but for a single sample, which showed insignificant excess against *MRL* set by the European Commission. However, there was bioaccumulation of *DDT* from soil into carrot, due to data obtained from *BCF* calculation. The presence of *DDT*

highlights the need for extensive monitoring entirely in Armenia to identify potential environmental risks and health risks to the population.

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Assessment of Microbial Safety of Cheese and Sausage Products Sold in the Supermarkets of the City of Yerevan

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ABSTRACT

The aim of this study is to assess the microbial safety of sliced sausage and cheese products sold in Yerevan. Microbiological indices defined by the Eurasian Economic Union (EAEU) technical regulations were studied in the products sampled from Nor Zovk, Yerevan City and SAS supermarkets. The results indicated that before being sliced in supermarkets, the studied food products met the established safety requirements. However, microbiological contamination was detected in 71.4 % of sliced sausage product samples and in 33.3 % of sliced cheese samples. Therefore, it can be concluded that cutting these food products at sale points can contribute to their microbial contamination, making these foods unsafe for consumption.

Introduction

Nowadays, sliced sausages and cheese are one of the most widely consumed ready-to-eat food products around the world due to their convenience and good acceptance by consumers (Rodriguez, et al., 2010). Meanwhile, microbial contamination of ready-to-eat food products is one of the major food safety and public health concerns for both developed and developing countries (Shiowshuh and Cheng-An, 2010).

Based on epidemiological and microbiological studies conducted by researchers in different countries, microbial cross-contamination either at home or production site is one of the major issues of food safety (Shiowshuh and Cheng-An, 2010, Ehrampoush, et al., 2017). Product can become contaminated via the environment, handlers and equipment, particularly slicing machines and cutting utensils during processing (Ehrampoush, et al., 2017). As a consequence, food items, including sausage and cheese products, can be contaminated with biological hazards, such as bacteria group of *Escherichia coli* (coliforms), mesophilic aerobic and facultative anaerobic microorganisms (MAFAM), Staphylococcus aureus (*S. aureus*), Listeri monocytogenes**,** salmonella (*Salmonella spp.*), sulfite-restoring clostridia, yeasts and molds.

Coliforms and MAFAM are considered as hygienic indicators. Consumption of foods rich in these types of bacteria can lead to gastrointestinal problems, accompanied by fever, dysbacteriosis, and nausea.

S. aureus is a facultative anaerobic bacterium, causes gastrointestinal diseases called staphylococcal food poisoning. Food contamination by *S. aureus* is caused by bacterial toxins that are resistant to heat and therefore cannot be destroyed during cooking (Le Loir, et al., 2003).

Listeria monocytogenes and *Salmonella spp.* are causes of most common foodborne diseases. Common symptoms of listeriosis include fever, muscle weakness and gastrointestinal problems. If the infection starts in the nervous system, the symptoms are headache, neck pain, anxiety, balance loss or convulsions. Salmonellosis causes diarrhea, abdominal pain and fever 8-72 hours after eating contaminated food (Bolton, et al., 2009).

Both molds and yeasts cause various degrees of deterioration and decomposition of foods. Several foodborne molds and yeasts may be hazardous to human health because of their ability to produce toxic metabolites known as mycotoxins (Tournas, et al., 2001).

Regarding sulfite-reducing clostridia, in the case of high amounts of these microorganisms, certain groups of people with low immune systems may develop acute intestinal infections, such as clostridiosis (Kouassi, et al., 2011).

Consumption of products contaminated with the abovementioned microorganisms is considered risky as it can have adverse effects on human health by causing food poisonings. Therefore, from the public health perspective, the quality and microbiological safety of food is very crucial. Hence, the aim of this study is to assess the microbial safety of cheese and sausage products sold in Yerevan.

Materials and methods

During the research, sausage products and cheese were randomly sampled from SAS, Nor Zovk, Evrika and Yerevan City supermarkets in Yerevan. A total of 10 composite samples were studied. Detailed information regarding the samples is presented in Table 1.

Sausage product and cheese samples were transported to the laboratory in sterile, hermetically sealed containers to prevent cross-contamination.

The presence of MAFAM, coliforms, *S. aureus, L. monocytogenes, Salmonella spp., sulfite-reducing clostridia,* yeasts and molds were studied in samples. In particular, both whole foods and sliced foods in supermarkets were studied to see if slicing the food at the retail stores possibly affects its microbial safety.

The methods for determining the presence of microorganisms in samples are presented in Table 2.

The analyses were carried out in "Standard Dialog" laboratory.

Table 1. Information on studied products*

Product type	Producer/product name	Code
Sausage products	Bacon /"Bagatir Balikovaya"	N1
	Bacon/"Bzhshkakan"	N2
	Moya Semya/"Smoked Singa"	N3
	Bari Samaratsi/"Germanakan"	N4
	Moya Semya/"Ham"	N5
	Atenk/"Gyumri"	N6
	Atenk/"Bzhshkakan"	N7
Cheese	Product containing processed (melted) cheese	N8
	"Badamere"	N9
	"Gauda"	N10

Table 2. Methods for the detection of the microbiological contamination*

Products	Code	Microorganisms	Methods
Sausage products and cheese samples	N2, N4, N5, N7, N8	MAFAM	GOST 0444.15-94
	N1-N10	Bacteria group *Escherichia coli* (coliforms)	GOST 31747-2012
	N1-N7, N9, N10	*S. aureus*	GOST 31746-2012
	N1-N10	Pathogenic bacteria, including *Salmonella spp.*	GOST R 50455-92
	N1-N10	Listeria monocytogenes	MUK 4.2.1122-02
	N1, N2, N4, N5, N6, N7	Sulfite-reducing clostridia	GOST 10444.9-88
	N8	Yeasts Molds	GOST 10444.12-2013

*Composed by the authors.

Results and discussions

The results indicate that the studied products met the requirements set by technical regulations (TRCU021/2011, TRCU033/2013, TRCU034/2013) before slicing and handling in the supermarket. However, microbial contamination was identified in several samples of sliced sausage and cheese products.

The contents of MAFAM in the studied samples of sausage products (N2, N4, N5, N7) and cheese (N8) are presented in Figure.

According to the data presented in Figure, MAFAM contents in the studied samples are in the range of $3.5x10^3$-$1x10^5$ CFU/g. The highest content of MAFAM was reported in N4 sausage product sample, and the lowest one in N5 sample. It shall be noted that in all the samples presented in the figure, MAFAM contents exceed the permissible level set by the EAEU technical regulations (TRCU 021/2011, TRCU 033/2013). The contents of MAFAM in the studied sausage products exceed the permissible level ($2.5x10^3$) by 1.4-40 times. MAFAM content in processed (melted) cheese (N8) exceeds the permissible level twice.

Similar study was carried out in the city of Tripoli, Libya. According to the study results, the contents of MAFAM ranged from $7x10^4$–$7.5x10^9$ CFU/g (Hamza&Elshrek, 2019). Comparing these outcomes with the current study results, it can be noted that the MAFAM contents were higher in the samples from Tripoli rather than those from Yerevan.

The content of MAFAM in samples of cheese products sold in Sudan supermarkets ranged from $6.0x10^6$ – $6.5x10^7$ CFU/g (Suleiman, et al., 2011), exceeding the MAFAM contents in cheese products of the current study by 300-32500 times.

Detailed information about the presence of microorganisms in the studied sausage products and cheese samples is presented in Table 3 and Table 4, respectively.

According to Technical Regulation of the Customs Union on Food Safety, the presence of bacteria group of *Escherichia coli* (coliforms) is not allowed in 0.1 g of product. However, according to the results of this study (Table 3), even though coliforms were not detected in cheese samples, it was detected in some samples of sausage product (N2, N3).

The presence of these bacteria can be a consequence of improper sanitary and hygienic conditions (work surfaces, utensils, personal hygiene of salespeople) at the retail stores (Bolton, et al., 2009). It should be noted that food contaminated with coliforms can be dangerous to human health, therefore, the studied products are not safe for consumption and shall not be sold in markets.

The results of another study indicate that the contents of coliforms in ready-to-eat products sold in the Slovakian supermarkets range from $10–1.6x10^3$ CFU/g, and are detected in 40 % of the samples (12/30) (Lopasovsky, et al., 2016).

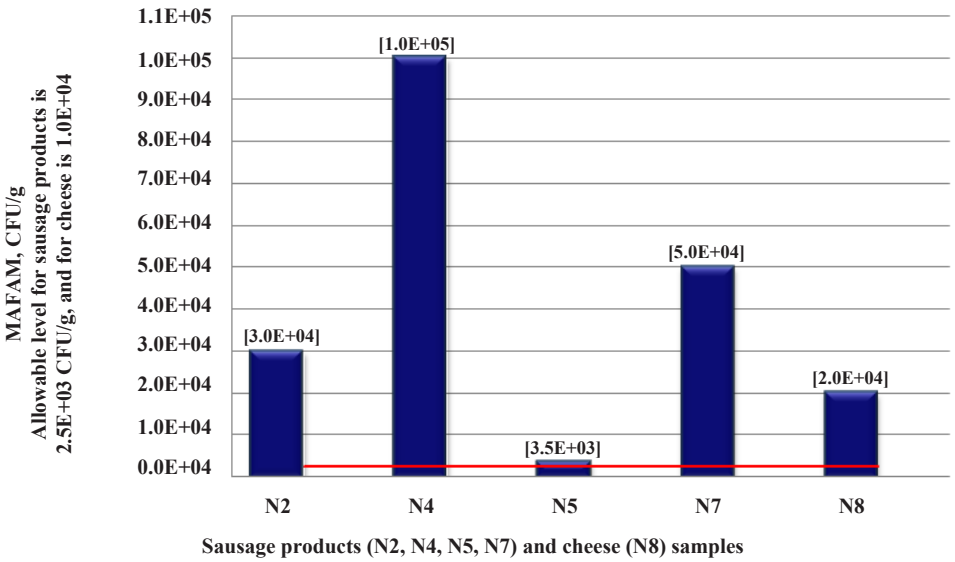

Figure. MAFAM content in samples (*composed by the authors*).

Table 3. Microorganisms in sausage products*

Sample codes	Coliforms	*S. aureus*	*Salmonella spp.*	*Listeria monocytogenes*	*Sulfite-reducing clostridia*
	Permissible level according to Technical Regulation (TR CU 021/2011, TR CU 034/2013)				
	n/a in 1 g	n/a in 1 g	n/a in 25 g	n/a in 25 g	n/a in 0.1 g
N1	n/d	n/d	n/d	n/d	n/d
N2	+	n/d	n/d	n/d	n/d
N3	+	n/d	n/d	n/d	n/d
N4	n/d	+	n/d	n/d	n/d
N5	n/d	n/d	n/d	n/d	n/d
N6	n/d	n/d	n/d	n/d	n/d
N7	n/d	n/d	n/d	n/d	n/d

Note. *n/a - not allowed, "+" - detected, "n/d" - not detected.*

Table 4. Microorganisms in cheese samples*

Sample codes	*Coliforms*	*S. aureus*	*Salmonella spp.*	*Listeria monocytogenes*	*Yeasts*	*Molds*
	Permissible level according to Technical Regulation (TR CU 021/2011, TR CU 033/2013)					
	n/a in 0.1 g	n/a in 0.001 g	n/a in 25 g	n/a in 125 g	<100 CFU	<100 CFU
N8	n/d	-	n/d	n/d	<10	<10
N9	n/d	n/d	n/d	n/d	-	-
N10	n/d	n/d	n/d	n/d	-	-

Note. *n/a - not allowed, "n/d" - not detected, "-" - the content of the microorganism wasn't investigated in the sample, CFU – colony forming unit*

*Composed by the authors.

Overall, according to the results of the microbiological safety assessment, *Listeria monocytogenes* and pathogenic bacteria, including *Salmonella spp.*, were not detected in the studied samples of sausage and cheese products. However, *S. aureus* was detected in one sample of sausage product (N4). It shall be highlighted that the presence of the latter in the ready-to-eat product is prohibited and is risky from the point of view of public health.

In 1 % of 2972 samples of sausage products sold in London supermarkets, the content of *S. aureus* was higher than 10^2 CFU/g and exceeded the acceptable level (the sufficient level is <20 CFU/g, the insufficient level is $1x10^2$–$1x10^4$ CFU/g, and the unacceptable or potentially dangerous level is ≥ $1x10^4$ CFU/g) (Gormley, et al., 2010).

The results of the study indicate that sulfite-reducing clostridia were not detected in the samples of sausage products, while yeasts and molds were not detected in the cheese samples.

Conclusion

According to the results of this study, the overall microbial contamination (MAFAM content) of 5 sliced sausage product samples (N2, N4, N5, N7, N8) and of 1 cheese sample from supermarkets in Yerevan exceed the maximum permissible level set by the EAEU Technical Regulations. In addition, coliforms were detected in 2 samples of sausage products (29 %) and *S. Aureus*

was detected in 1 sample of sausage products (14 %). Overall, the results of the study indicate that 71.4 % of sausage products samples and 33.3 % of cheese samples do not meet food safety requirements and are dangerous to consumer health since their consumption can lead to food poisoning.

Therefore, in order to prevent microbial contamination, it is necessary to follow the proper safety and hygiene requirements in the supermarkets. This will minimize microbiological risks of food by effectively controlling all food-related processes in the supermarket and ensuring the safety of ready-to-eat products.

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