

CURRENT ISSUES OF FOOD SAFETY AND QUALITY: STATUS AND PROSPECTS OF DETERMINATION

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Abstract. The prerequisite for the recovery of Ukraine's economy is the use of the existing sea potential and the capabilities of the domestic maritime industry along with the land one. The current state of determining the quality and safety of food products is characterized. Changes in the most heat-labile vitamin – ascorbic acid, as a criterion for assessing the preservation of the biological value of food products, were determined. Losses of the vitamin were established based on the results of measuring the effect of temperature on the concentration of ascorbic acid and showed the possibility of its destruction up to 66% in a food sample and up to 80% in its model solution during sea transportation along the route of the Bosphorus Express line in the absence of air conditioning. The results of own research on the integral determination of product safety by biotesting are presented. Modeling of the influence of negative factors on the degree of survival of selected test cultures was carried out on model mono- and polytoxicants and product samples for representatives of the main dominant groups of toxic compounds – pesticides of various chemical nature, mycotoxins, heavy metals. A comparative assessment of the monitoring of test cultures for biotesting on models and product samples showed an increased indication for *Stylonichia mytilus* compared to *Daphnia magna* Straus. This makes it possible to use *Stylonichia mytilus* for the accelerated indication of a wide list of known, emerging, and even unknown as dangerous toxic substances of different chemical nature. A method of biotesting to determine the safety of food products at various stages of its life cycle has been developed and implemented, which is one-stage, prioritized thanks to the developed automated system of express analysis of the safety of food products. The developed method is approved and approved for use in the food industry by the Ministry of Agrarian Policy of Ukraine as the Rules of Established Practice (RuEP).

Keywords: food products, safety, quality, biotesting, *Stylonichia mytilus*, *Daphnia magna* Straus, sea transportation, biosafety.

Introduction. Formulation of the problem

Ukrainian food products are in demand on all continents. At the same time, domestic manufacturers have great potential for growth and are interested in expanding product exports. The issues of sanitation, food safety, transport, in particular maritime safety, are very relevant for ensuring the economic stability of Ukraine. The current global trend is a sharp increase in the number of low-quality and counterfeit food products. That is why the issue of food safety, the state and prospects of determining their quality and safety is the main aspect of preserving the health of consumers and the biodiversity of the planet.

Analysis of recent research and publications

Ensuring the protection of human life and health, observance of the rights and legitimate interests of consumers is one of the most important principles of European policy, the standards of which Ukraine is now striving to achieve in connection with the need to fulfill obligations under the Association Agreement between Ukraine and the European Union [1]. Reforming the system of state control over the quality and safety of food products has gained fundamental relevance, and the adoption of Law No. 2042-VIII by the Verkhovna Rada was a significant step for this.

One of the safe trade sea routes for export and import supplies of food products, including the route of

the Bosphorus Express-Asia-Black Sea line (Odessa, Illichivsk Ukraine – Dalian China), is presented in fig. 1. The route runs through different climatic zones of the earth's layer, therefore various circumstances arise that can lead to the emergence of dangerous situations regarding the safety of food products [2,3].

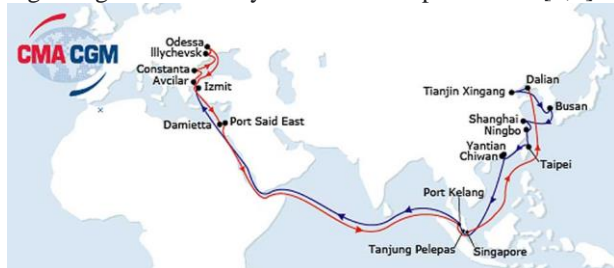


Fig. 1. Bosphorus Express-Asia-Black Sea route

Transportation of food products is possible only under certain conditions (temperature, humidity, regulated by air conditioning, etc.), the parameters of which depend on the type of products being transported. In modern market conditions, both strict production control, which is carried out by the manufacturer of food products with the determination of potential risks of contamination of the final product, and state supervision of its safety must be carried out. At the legislative level, this is fixed in the form of a requirement for mandatory implementation of the food safety management system based on HACCP [3-5].

Risks related to the food security of the state include the delivery and transportation of food export and import products. In the national transport strategy of Ukraine for the period until 2030 [3], it is noted that the state operates a developed network of ferry connections, sea container lines connecting Ukraine with partner countries in the Black Sea region, and the creation on the basis of public-private partnership is a priority international cooperatives, companies — transportation operators interested in increasing the volume and efficiency of transportation in the relevant market segments. Europol and Interpol have released the results of the coordinated operation OPSON 2020, which lasted from December 2019 to June 2020 with the participation of law enforcement agencies from 83 countries and was also supported by the European Anti-Fraud Office (OLAF), the European Commission, the European Union Intellectual Property Office (EUIPO), national food regulatory authorities and partners from the private sector [6,7]. The purpose of the operation was to identify low-quality food and beverages that can be found on store shelves around the world and that pose a serious threat to public health. The authorities of Bulgaria, Italy, France, Greece, Portugal and Switzerland drew attention to dairy products. As a result, 320 tons of contraband or low-quality dairy products were seized. The national bodies of the countries seized spoiled milk and cheese, which posed a threat to the health of consumers. In Bulgaria, during the investigation of the activity of an unregistered composition of products,

seven samples of cheese were found with a positive test result for the content of starch and *E. coli*. The authorities seized 3.6 tons of dangerous dairy products that were supposed to be processed into processed cheese.

The modern development of science and technology allows to create and apply express methods, devices for determining the quality and safety of food products [8-11].

The global and domestic practice of standardizing quality control indicators establishes two groups of criteria for such product evaluation [12-15]:

- safety indicators;
- indicators of composition, nutritional and biological value.

Along with this, a significant number of various indicators for this definition makes it practically impossible to fully characterize the quality, safety and authenticity of food products. That is why accelerated methods of integral determination of the safety of food products are gaining relevance.

The purpose and objectives of the research. The purpose of the work was to analyze and characterize the methods of determining the safety and quality of food products, to develop methods of integral and accelerated assessment of the safety of food raw materials and products of their processing, as well as to establish the impact of sea transportation on its quality.

To achieve the formulated goal, the following tasks were specified:

- monitor the selection of relatively universal test cultures, indicative of a wide range of toxicants that have different mechanisms of influence on biological objects, for conducting biological studies;
- determine the integral safety of food raw materials and products in relation to the list of regulated toxic substances, create a qualitative evaluation of biotesting with an automated system of express analysis of food safety.
- determine the influence of physical and chemical factors and transportation of products on their potential quality and safety.

Research materials and methods

When setting up the experiment, model solutions of the main groups of various types of toxic substances of organic and inorganic nature, characteristic of contamination of food raw materials, were used – solutions of salts of heavy metals (lead, cadmium, mercury, tin, zinc, chromium, etc.) and a number of traditionally used pesticides (organochlorine and organophosphorus nature), as well as metabolic products of microbiological pathogens of spoilage of food raw materials. Samples were analyzed using pesticides (Fosalon, Tilt, Buldoc, Decis, etc.), as well as metabolic products of pathogens of microbiological spoilage of food raw materials - micromycetes of the genera *Penicillium*, *Aspergillus* and mixed cultures of

microorganisms of the genera Colletotrichum, Aureobasidium, Pullularia, etc.

The following were used as research objects:

- model solutions of the listed substances in various concentrations from 0.1 to 5.0 MPC (maximum permissible concentration);

- types of raw materials with different biochemical composition, physico-chemical and structural-mechanical properties, namely: apples, tomatoes, cucumbers, plums, cheese, grapes, quince as species that are quite significant in terms of consumption;

- a number of samples from the listed types of researched products with the introduction of model mono- and polytoxicants.

Infusoria *Stylonichia mytilus* and crustacean *Daphnia magna* Straus, recommended for monitoring the quality of water and other environments, were used as test cultures. The degree of toxicity was determined by the survival of test cultures using the toxicity table. In the presence of toxic compounds in the product, the ciliates underwent disintegration - lysis.

The survival of the test culture was calculated according to the formula:

$$N = (N2 / N1) \cdot 100$$

where N is survival, %;

- N2 – arithmetic average (from five studies) of the number of ciliates after 1 hour of exposure, pcs.;

- N1 – arithmetic average (from five studies) of the number of ciliates at the beginning of the experiment, units;

- 100 is a percentage conversion factor.

The degree of toxicity of the studied drug was determined according to Table 1 [15].

Thermostatic modeling of the effect of temperature on the most labile component of food products (vitamin C) was carried out. For this purpose, two types of model solution samples were prepared: 1-st – aqueous solution of ascorbic acid with a concentration of 1000 mg/dm³ (pH 5.0–5.4) and 2-nd – homogenate of apples with the introduction of ascorbic acid in a similar concentration. The obtained samples were kept for 1 day in a thermostat at the temperatures indicated in the Table 2. In the samples taken from these model samples, the concentration of vitamin C was determined by the titrimetric method [16].

Table 1 – The degree of toxicity of the studied sample

The degree of toxicity of the research object	Survival of ciliates, %
Non-toxic	80–100
Mildly toxic	50–79
Toxic	0–49

Standard and generally accepted in practice physico-chemical, microbiological and biochemical methods of research were also used for conducting research [17].

The results of experimental studies were processed by methods of mathematical statistics and modeling, as given in [15,18].

Results of the research and their discussion

As is known from the analytical review, the safety of food products must be guaranteed throughout the chain of its life cycle: cultivation of food raw materials, production, transportation, storage and sale. Table 2 shows an approximate daily schedule of temperature changes on the trade sea route of the Bosphorus Express line in containers during the transportation of food products along the specified route, which is covered in 24–26 days, and the change in the concentration of ascorbic acid in model systems.

Table 2 – Influence of average daily temperature in containers on the concentration of ascorbic acid

Hours of the day, h-min	The temperature of the container with the food product in the container, °C [2,3]	Concentration of ascorbic acid in a model solution, x 10 ⁻³ %	
		1	2
0–00	15–18	100±2	138±4
1–00	12–15	99±3	130±6
2–00	11–12	97±2	124±3
3–00	10–12	96±4	120±2
4–00	10–12	93±2	116±5
5–00	10–12	91±4	112±4
6–00	11–12	89±2	109±4
7–00	15–18	87±5	102±7
8–00	15–18	84±3	100±2
9–00	20–25	79±8	94±6
10–00	25–28	71±4	89±3
11–00	32–35	64±6	82±2
12–00	35–38	55±5	78±4
13–00	37–40	51±3	70±2
14–00	37–40	48±5	67±6
15–00	38–40	43±2	63±2
16–00	38–40	40±4	60±2
17–00	38–39	37±2	58±5
18–00	38–39	33±6	55±2
19–00	35–37	30±3	53±6
20–00	33–35	28±5	52±2
21–00	30–32	24±2	49±3
22–00	25–26	21±3	48±2
23–00	20–21	20±2	47±3

Listed in the Table 2, the results of measuring the temperature values and concentration of ascorbic acid show that the destruction of the labile vitamin is possible – up to 80% for its model solution and smaller losses – up to 66% in the apple sample, probably due to the presence in it of compounds that stabilize ascorbic acid, in particular polyphenols. Thus, at the indicated temperature regimes of transportation, in order to preserve the quality and safety of food products, it is desirable to carry out at this important stage of the life cycle of the products its cooling by one of the known methods and not to violate the specified transportation terms.

From the analytical review, it follows that food products are the main source of the penetration of toxic substances into the human body from the external environment, the range of which is practically impossible to identify by chemical methods. In connection with the practically unpredictable effect of several harmful substances on the human body, the issue of their detection and integral impact on the body becomes even more complicated. Modern methods of controlling the safety and quality of products should be especially related to indicators characterizing the degree of integral impact on the human body of a wide range of toxicants of various nature – contaminants of chemical, microbial and other origin. That is why in recent decades, the creation of a relatively rapid assessment of the quality and safety of products using biological methods has become relevant. Biotests were monitored according to the following criteria: high sensitivity to a wide range of analyzed substances; technical simplicity; availability of test organisms, materials and equipment for analyses; safety and prevention of additional environmental pollution; standardization and easy reproducibility made it possible to select ciliates *Stylonychia mytilus* and crustaceans *Daphnia magna Straus*.

The selection of the primary test organisms tested and recommended for biological evaluation of the degree of toxicity of various objects was also determined by the fact

that the lower crustacean *Daphnia magna Straus* is the traditional test organism used in ecotoxicological tests included in the standard bioassay programs of the U.S. Environmental Protection Agency (EPA), International Organization for Standardization (ISO) standard.

The results of studies to establish the indicativeness of biotesting for heavy metals, pesticides and complex toxicants are shown in Tables 3–8. We studied the effect of heavy metal salts (Cd^{2+} , Pb^{2+} , Hg^{2+} , Sn^{2+} , Cu^{2+} , Zn^{2+} , Cr^{6+}) in model solutions of different concentrations on the degree of their toxicity to *Stylonychia mytilus*. In order to identify the indicativeness of the test organism to the specified toxicants, the study began with a concentration of 0.1 MPC and continued to increase to 5.0 MPC. The influence of the concentration of heavy metal ions in model solutions on the degree of their toxicity for *Stylonychia mytilus* is shown in Table 3.

It was established that the survival of *Stylonychia mytilus* ciliates in model solutions is affected by the type of toxicant and its concentration.

The behavior of test cultures under the influence of heavy metal ions in real food samples and with the addition of heavy metal salts was also studied. The assessment of the toxicity of apple juice with the introduction of monotoxicants is given in the Table 4, and for plum juice in Table 5.

Table 3 – Toxicity of heavy metal salt solutions for *Stylonychia mytilus* (n=3, P ≥ 0.95)

Type of contaminant	Concentration MPC	The number of ciliates at the beginning of the experiment/after 1 hour of exposure, pcs.	Survival of ciliates, %	The degree of toxicity of the sample
Hg(NO ₃) ₂	0.10	64±2 / 53±2	82.9	Non-toxic
	0.25	127±4 / 80±3	62.9	Slightly toxic
	0.35	181±7 / 72±2	39.8	Toxic
	0.50	134±4 / 55±2	4.1	Toxic
	0.75	138±5 / 3±1	2.2	Toxic
	1.0	146±4 / 0	0	Toxic
SnCl ₂	0.1	139±5 / 133±6	95.7	Non-toxic
	0.25	142±6 / 132±3	93.0	Non-toxic
	0.5	130±4 / 88±3	67.7	Slightly toxic
	1.0	125±6 / 50±1	40.0	Toxic
	2.0	84±2 / 2±0	2.4	Toxic
CuSO ₄	0.10	150±6 / 18±2	78.7	Slightly toxic
	0.5	121±5 / 3±1	2.5	Toxic
	1.0	125±6 / 0	0	Toxic
ZnSO ₄	1.0	82±3 / 32±2	39.0	Toxic
	0.50	77±3 / 51±3	66.2	Slightly toxic
	0.25	56±2 / 52±1	92.9	Non-toxic

Table 4 – Toxicity of apple juice with introduction of Cr+6 model solutions for *Daphnia magna Straus*

Concentration Cr ⁶⁺ , MPC	The number of ciliates at the beginning of the experiment/after 1 hour of exposure, pcs.	Survival of ciliates, %	The degree of toxicity of the sample
0.25	53 ±1 / 48±0	90.6	Non-toxic
0.5	88±2 / 57±1	64.8	Slightly toxic
1.0	85 ±3 / 33±2	38.8	Toxic
2.0	71±2 / 21±1	29.6	Toxic
3.0	73 ±3 / 19±2	26.0	Toxic
4.0	67±2 / 12±1	17.9	Toxic
5.0	83±2 / 5±0	6.0	Toxic

Note: MPC for chromium salts is 0.0002 mg/cm³

Table 5 – Toxicity of plum juice containing toxicants to *Stylonychia mytilus* (n=3, P ≥ 0.95)

Type of sample and toxicant	Toxicant concentration, MPC		Survival <i>Stylonychia mytilus</i> , %	Degree of toxicity
	Cd ²⁺	Pb ²⁺		
Water (control)	—	—	100.0	Non-toxic
Plum juice	—	—	98.6	Non-toxic
Pb ²⁺	—	1.0	39.7	Toxic
Pb ²⁺	—	2.0	22.5	Toxic
Cd ²⁺	1.0	—	39.5	Toxic
Cd ²⁺	2.0	—	19.4	Toxic
Pb ²⁺ + Cd ²⁺	1.0	1.0	24.3	Toxic

Note: MPC Pb²⁺ = 0.5 mg/cm³; MPC Cd²⁺ = 0.03 mg/cm³.

It is important to note the high indicativeness of biotesting on the studied types of test crops for toxic elements, which is slightly inferior to the data specified in [16] beyond their detection limit by atomic absorption analysis (AAC method).

In order to clarify the relative universality of the recommended test cultures for conducting biological research, a wide range of drugs used in the cultivation of plant raw materials, which have different mechanisms of influence on biological objects, were studied. During the study of the toxicity of the samples,

pesticides used in agrotechnical practice, as well as their compositions, were used as toxic substances. The action of the specified toxicants was studied in different concentrations: for pesticides, the study was started with 0,1 MPC and then, by analogy with salts of heavy metals, up to 1.5–6.0 MPC.

The results of studies of the effect of pesticides used during the cultivation of fruit and vegetable crops on model solutions of the insecticides "Fozalon", "Buldok" and systemic fungicide "Tilt" in different concentrations are shown in Fig. 2 and in Table 6.

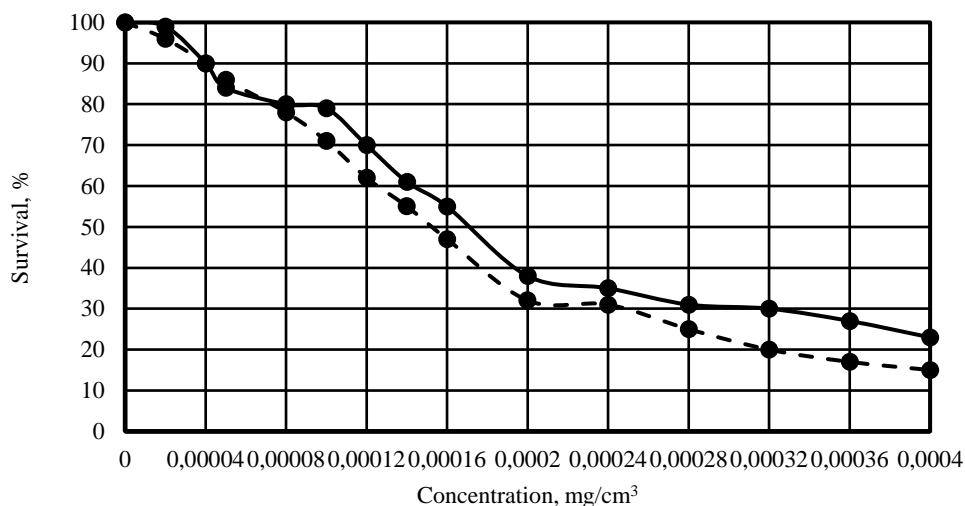


Fig. 2. Survival of *Stylonychia mytilus* in "Fozalon", "Buldok" preparations of different concentrations (MPC of Phozalon - 0,0002 mg/cm³, MPC of Bulldog - 0,0002 mg/cm³).

Table 6 – Influence of the concentration of "Tilt" model solutions on the degree of their toxicity (according to the survival of *Stylonychia mytilus*) (n=3, P ≥ 0.95)

Concentration of "Tilt", MPC	Number of ciliates at the beginning of the experiment/after 1 hour of exposure, pcs	Survival of ciliates, %	Degree of toxicity
0.1	84±7 / 82±3	97.6	Non-toxic
0.25	79±3 / 71±4	89.9	Non-toxic
0.3	76±3 / 65±5	85.5	Non-toxic
0.5	80±2 / 57±4	71.3	Non-toxic
0.75	79±6 / 40±2	50.6	Slightly toxic
1.0	68±3 / 23±2	33.8	Toxic
1.25	72±4 / 23±2	31.9	Toxic
1.5	64±4 / 12±1	18.8	Toxic

Note: MPC tilt – 0.0002 mg/cm³.

These results show that the dose-effect relationship is non-linear, and the type of pesticide has a smaller effect on the survival of the test culture than the concentration of the toxicant. It should be especially noted that this method allows for the indication of pesticides of the studied species in low concentrations (less than 1,0 MPC), which indicates the sensitivity of the method and the possibility of its use for the detection of this group of toxic chemicals. Similar data were obtained for another widely used insectoacaricide, sevin.

The above results also show that the test organism is slightly less sensitive to the indication of heavy metal ions than pesticides in concentrations of 1,0 or more MPC. This can be explained by the peculiarities of the effect of toxicants on organisms and cell structures of test cultures, as well as the possibility of binding heavy metal ions by the components of juicy plant material, in particular, its biopolymer structures. The latter can be confirmed by the fact that lead ions in model solutions show somewhat higher toxicity compared to their effect on test cultures in real product samples.

Assuming the possibility of contamination of raw materials with complex composite toxicants, a study of the effect of a mixture of pesticides on test crops was conducted (Table 7). Judging by the obtained results, the complex pesticide practically does not violate the trends obtained for individual toxicants, the indicator of general toxicity is also related to the concentration in

these experiments. The type of toxicant or their composition has little effect on the studied indicator. Given the fact that pesticides and heavy metals can be found simultaneously in real objects, their complex influence on the survival of *Stylonychia mytilus* was studied. The results of studies of the degree of toxicity of model solutions of a mixture of pesticide and heavy metals are shown in Table 8.

Judging by the obtained results, the effect in most experiments is related to the total effect of the studied toxicants and, as a rule, is not accompanied by the phenomenon of potentiation.

The study of the complex effects of toxic substances of different classes on biological objects used as test cultures was also carried out in real samples of plant food products. The results of the study of the effect of the pesticide sevin (alpha-naphthyl-N-methylcarbamate), which is considered a substitute for DDT, and CdCl₂ on the survival of *Stylonychia mytilus* in plum juice are shown in Table 9.

In order to evaluate the indicativeness of the test cultures used for biotesting, the recommendations of the Codex Alimentarius Commission regarding the required sensitivity of the pesticide analysis method were taken into account. The Commission proposes to consider the sensitivity of the method as acceptable if the smallest calibration level does not exceed the given values (Table 10) [16].

Table 7 – Toxicity of the mixture of fungicide tilt (propiconazole) and insecticide decis (alpha-cypermethrin) to *Stylonychia mytilus* (n=3, P ≥ 0.95)

Concentration of decis, MPC	Concentration of tilt, MPC	Total number of <i>Stylonychia mytilus</i> at the beginning of exposure/after 1 hour of exposure, pcs	Survival of <i>Stylonychia mytilus</i> %	Degree of toxicity
0.25	0.25	65 / 47	72.3	Non-toxic
0.3	0.3	62 / 39	62.9	Slightly toxic
0.4	0.4	63 / 32	50.8	Slightly toxic
0.3	0.5	65 / 32	49.2	Slightly toxic
0.5	0.5	64 / 31	48.4	Slightly toxic
1.0	1.0	62 / 22	35.5	Toxic
1.5	1.5	66 / 19	28.8	Toxic
2.0	2.0	60 / 9	15.0	Toxic

Note: MPC of tilt fungicide is 0.0002 mg/cm³;

MPC of decis insecticide is 0.0001 mg/cm³.

Table 8 – The influence of the concentration of a complex toxicant (fozalon + Cd²⁺) on the degree of toxicity of model solutions (n=3, P ≥ 0.95)

Concentration of toxicants, MPC		Survival of ciliates <i>Stylonychia mytilus</i> , %	The degree of toxicity of the sample
fozalon	Cd ²⁺		
0.1	0.1	95.1	Non-toxic
0.25	0.25	81.1	Non-toxic
0.3	0.3	69.6	Slightly toxic
0.5	0.5	50.0	Slightly toxic
0.75	0.75	31.7	Toxic
1.0	1.0	20.5	Toxic
1.25	1.25	12.7	Toxic
1.5	1.5	7.2	Toxic

Note: MPC of Phosalon = 0,0002 mg/cm³;

MPC Cd²⁺ = 0,00003 mg/cm³

Table 9 – Toxicity of plum juice with the addition of toxicants to *Styloynchia mytilus* (n=3, P ≥ 0.95)

Concentration of toxicants, MPC		Survival of <i>Styloynchia mytilus</i> , %	The degree of toxicity of the sample
sevin	Cd ²⁺		
0.25	0.25	81.0	Non-toxic
0.5	0.5	49.2	Slightly toxic
1.0	1.0	27.3	Toxic
2.0	1.0	8.1	Toxic

Note: MPC of sevin= 0.0001 mg/cm³; MPC of Cd²⁺ = 0.00003 mg/cm³

Table 10 – Requirements for the sensitivity of the method of analysis of residual amounts of pesticides

The maximum permissible level (MPL) of residual amounts of the pesticide, mg/kg	The smallest calibration level of the pesticide, mg/kg
≥ 5	0.5
0.5 – 5	0.1 – 0.5
0.05 – 0.5	0.02 – 0.1
<0.05	0.5 MPL

The trends revealed for *Styloynchia mytilus* can be traced in setting up the experiment on other test cultures, in particular *Daphnia magna Straus*. Analyzing the given results of biotesting, it should be noted that both test cultures – *Styloynchia mytilus* and *Daphnia magna Straus* – meet the requirements of indication for different types of pesticides by chemical nature, as they react to their concentrations corresponding to 0,5 MPL.

The indication of biotesting of toxic metabolites of mixed cultures of microorganisms was also established. Various types of raw materials that underwent spontaneous types of microbiological deterioration were chosen as substrates for the study. The causative agents of spoilage were identified by the characteristic properties available in microbiology – morphological and cultural signs. In the Table 11 shows some of the research results separately for the water-soluble and lipo-soluble fractions containing the metabolic products of these pathogens of food spoilage.

Table 11 – Evaluation of the toxicity of metabolic products of pathogens of microbiological spoilage of food products

Researched material	Causes of spoilage of raw materials	Number of individuals of <i>Styloynchia mytilus</i> at the beginning/after 1 hour of exposure	Survival of <i>Styloynchia mytilus</i> , %	Degree of toxicity
Lipo-soluble fractions				
Cucumbers (Odessa region)	Micromycetes genus <i>Penicillium</i>	58±2 / 50±1	82.2	Non-toxic
Cucumbers (Mykolaiv Region)	Mixed cultures of microorganisms of genera <i>Colletotrichum</i> , <i>Aspergillus</i>	48±3 / 7±4	14.6	Toxic
Apples	Mixed cultures of microorganisms of genera <i>Aureobasidium</i> , <i>Pullularia</i> , <i>Aspergillus</i>	59±2 / 13±3	22.0	Toxic
Quince	Mixed cultures of microorganisms of genera <i>Aureobasidium</i> , <i>Pullularia</i> , <i>Aspergillus</i>	61±2 / 30±2	49.2	Slightly toxic
Grape	<i>Phoma</i>	58±3 / 28±1	48.2	Slightly toxic
Tomatoes	Mixed cultures of microorganisms of genera <i>Penicillium</i> , <i>Pullularia</i> , <i>Aspergillus</i>	76±2 / 12±2	15.8	Toxic
Cheese	Mixed cultures of microorganisms of genera <i>Penicillium</i> , <i>Endomyces</i>	67±2 / 3±2	4.5	Toxic
Water-soluble fractions				
Cucumbers (Odessa region)	Micromycetes genus <i>Penicillium</i>	60±2 / 52±3	86.7	Non-toxic
Cucumbers (Mykolaiv Region)	Mixed cultures of microorganisms of genera <i>Colletotrichum</i> , <i>Aspergillus</i>	57±2 / 53±1	93.0	Non-toxic
Tomatoes	Mixed cultures of microorganisms of genera <i>Penicillium</i> , <i>Pullularia</i> , <i>Aspergillus</i>	80±4 / 40±1	50.0	Slightly toxic
Quince	Mixed cultures of microorganisms of genera <i>Aureobasidium</i> , <i>Pullularia</i> , <i>Aspergillus</i>	52±2 / 52±2	100.0	Non-toxic
Cheese	Mixed cultures of microorganisms of genera <i>Penicillium</i> , <i>Endomyces</i>	68±4 / 58±3	76.71	Slightly toxic

As it follows from the above results, toxicity is characteristic for lipo-soluble fractions of raw materials in most cases, while toxicity or weak toxicity was established for water-soluble fractions only for some samples. This may indicate the presence of mycotoxins, the characteristic feature of which is insolubility or weak solubility in water, in the metabolic products of the identified microorganisms that cause spoilage of raw materials.

The mathematical processing of the obtained results made it possible to develop a computer program for an automated system of express food safety analysis, the priority of which is registered by the intellectual property body of Ukraine [20]. The developed program makes it possible not only to register the degree of toxicity of the studied samples of food products, but also to more clearly differentiate the danger zone of the research object, as well as to specify the quantitative characteristics of the alleged contaminants. In addition, it is possible to predict the range of concentrations of contaminants that dominate the product. A comparative assessment of the sensitivity of the studied test cultures

to cadmium ions and other studied inorganic and organic toxicants allows us to note a higher sensitivity of *Stylonychia mytilus* compared to *Daphnia magna S.*, which allows us to recommend the use of these organisms as test cultures. These developments are a priority and some of the results of these studies are shown in fig. 3 (a, b).

Judging by the obtained results, it was concluded that the complex toxicant has a more intensive negative effect on the tested test cultures than individual toxicants. This is confirmed by the coefficients of logarithmic dependencies in Fig. 3a and 3b, respectively, for the complex toxicant and cadmium. The research results showed that the same trends are observed for other complex toxicants, namely heavy metals, pesticides, mycotoxins and other compounds. These developments, reflecting the relationship between the concentration of toxic compounds and the results of biotesting, substantiate the creation of new scientific approaches to the qualitative assessment of biotesting, which we proposed for the first time [16,19,21].

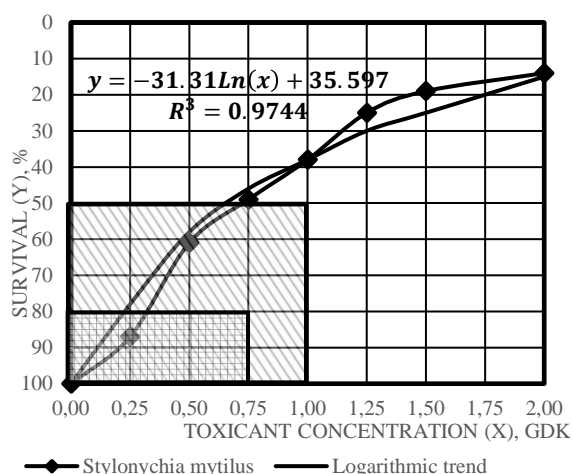


Fig. 3a. The effect of cadmium salt solutions on the test-culture *Stylonychia mytilus*

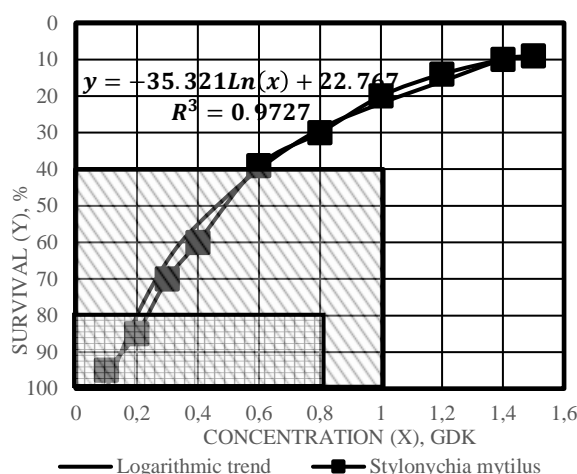
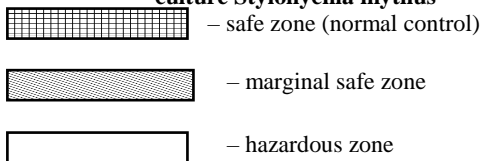


Fig. 3b. The effect of a complex toxicant (Fosalon pesticide + cadmium chloride) on *Stylonychia mytilus*

Conclusion

The analytical review analyzed the current state and prospects of determining the quality and safety of food products, identified hazard factors, the methodology of their determination, and the need for more sensitive and effective methods for the analysis of a wide range of food products.

The monitoring of test cultures made it possible to choose for biological research the ciliates *Stylonychia mytilus* and the crustacean *Daphnia magna Straus* based on their indication for a wide range of toxicants with

different mechanisms of influence on biological objects, technical simplicity, safety and the absence of additional environmental pollution, standardization and easy reproducibility .

Modeling of the influence of negative factors on the degree of survival of selected test cultures was carried out on model mono- and polytoxicants and product samples for representatives of the main dominant groups of toxic compounds – pesticides, mycotoxins, heavy metals. For the first time, an automated system for rapid analysis of the safety of various types of food raw materials was developed, and a biological

assessment of the dependence of the functioning of test organisms on the concentrations of individual toxic substances and their compositions was carried out — a qualitative evaluation of biotesting was carried out. The developed method is approved and approved for use in the food industry by the Ministry of Agrarian Policy of Ukraine as the Rules of Established Practice – RuEP.

According to the degree of destruction of ascorbic acid as a heat-labile component of food products, it was established that non-compliance with the temperature regimes and terms of transportation of food products by sea transport on the most economical routes can lead to

a significant decrease in the quality and safety of these transport cargoes.

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АКТУАЛЬНІ ПИТАННЯ БЕЗПЕКИ ТА ЯКОСТІ ПРОДУКТІВ ХАРЧУВАННЯ: СТАН ТА ПЕРСПЕКТИВИ ВИЗНАЧЕННЯ

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Анотація. Передумовою відновлення економіки України є використання поряд з сухопутним наявного морського потенціалу та можливостей вітчизняного морського господарства. Охарактеризовано сучасний стан з питань визначення якості і безпеки харчової продукції. Визначено зміни **найбільш** термолабільного вітаміна – аскорбінової кислоти, як критерія оцінки збереження біологічної цінності харчових продуктів. Встановлено втрати вітаміну за результатами виміру впливу температури на концентрацію аскорбінової кислоти та показано можливість її руйнування до 66% у харчовому зразку і до 80% у її модельному розчині протягом морського транспортування маршрутом лінії Bosporus Express при відсутності кондиціювання. Наведено результати власних досліджень з інтегрального визначення безпечності продукції біотестуванням. Проведено моделювання впливу негативних чинників на ступінь виживання обраних тест-культур на модельних моно-, політоксикантах і зразках продукції для представників основних домінуючих груп токсичних сполук – пестицидів різної хімічної природи, мікотоксинів, важких металів. Порівняльна оцінка моніторингу тест-культур для біотестування на моделях і зразках продукції показала підвищену індикативність для *Styloichia mytilus* в порівнянні з *Daphnia magna Straus*. Це дає можливість застосування *Styloichia mytilus* для прискореної індикації широкого переліку відомих, емерджентних і навіть невизначених як небезпечні, різних за хімічною природою токсигенних речовин. Розроблено і впроваджено спосіб біотестування для визначення безпечності харчової продукції на різних етапах її життєвого циклу, який є одноетапним, пріоритетним завдяки розробленій автоматизованій системі експрес-аналізу безпечності харчових продуктів. Розроблений спосіб схвалений і затверджений для застосування в галузях харчової промисловості Міністерством аграрної політики України як Правила усталеної практики – ПрУП.

Ключові слова: харчові продукти, безпека, якість, біотестування, *Styloichia mytilus*, *Daphnia magna Straus*, морські перевезення, біобезпека.