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ASSESSMENT OF POTENTIAL HAZARD FOR HUMANS WHEN EATING APPLES AND GRAPES TREATED WITH INSECTICIDE BASED ON SPIROMESIFEN

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Key words: *spiromesifen, maximum residue levels, apples, grapes, consumption safety*

Abstract. *Assessment of potential hazard for humans when eating apples and grapes treated with insecticide based on spiromesifen. Tkachenko I.V., Antonenko A.M., Bardov V.G., Omelchuk S.T. Chemical plant protection products account for at least 3 % of all biosphere pollutants and are the most studied pollutants on our planet. A very significant potential risk to public health is the consumption of foodstuffs contaminated with residual quantities of pesticide compounds. The aim of the work was to assess the potential hazard to humans when eating apples and grapes treated with an insecticide based on spiromesifen. A stepwise study was used: the content of spiromesifen in apples and grapes was calculated; the risk to humans was assessed (comparing the values of the permissible daily intake of the compound with food products with the maximum possible daily intake); the integral hazard index of pesticide-contaminated products consumption was calculated and assessed. The results obtained for the determination of residual amounts of spiromesifen in apples and grapes made it possible to substantiate the value of its maximum allowable value – 0.02 mg/kg; apple and grape juices – 0.01 mg/kg. It was found that the actual intake of spiromesifen with apples and grapes can be 0.0065 mg, and this does not exceed 0.5% of the permissible daily intake, or 0.7% of the estimated permissible amount of spiromesifen that can be consumed with food. According to the value of the integral index of hazard in contaminated food consumption (6 points) spiromesifen belongs to class 3 – moderately dangerous to humans. It has been established that substantiated standards for spiromesifen make it possible to ensure the safety of consumption of grapes and apples grown with the Oberon Rapid 240 SC application, as well as the use of other pesticide formulations based on this substance on other crops.*

Реферат. *Оцінка потенційної небезпечності для людини при вживанні яблук і винограду, оброблених інсектицидом на основі спіромезифену. Ткаченко І.В., Антоненко А.М., Бардов В.Г., Омельчук С.Т. Хімічні засоби захисту рослин становлять не менше ніж 3% усіх забруднювачів біосфери і є найбільш вивченими забруднювачами нашої планети. Досить вагомий потенційний ризик для здоров'я населення становить вживання продуктів харчування, контамінованих залишковими кількостями пестицидних сполук. Мета роботи – оцінка потенційної небезпечності для людини вживання яблук і винограду, оброблених інсектицидом на основі спіромезифену. Для досягнення мети нашої роботи використовували поетапне дослідження: розраховували вміст спіромезифену в яблуках та винограді; оцінювали ризик для людини (порівняння величин допустимого добового надходження сполуки з харчовими продуктами з максимально можливим добовим надходженням); розраховували та оцінювали інтегральний показник небезпечності при вживанні харчових продуктів, контамінованих пестицидами. Отримані результати в визначення залишкових кількостей спіромезифену в яблуках та винограді дозволили обґрунтувати в якості максимально допустимого рівня величину – 0,02 мг/кг; яблучному й виноградному соках – 0,01 мг/кг. Установлено, що фактичне надходження спіромезифену з яблуками та виноградом може становити 0,0065 мг, і це не перевищує 0,5% від допустимого добового надходження, або 0,7% від розрахункової допустимої кількості спіромезифену, яка може надійти в організм з харчовими продуктами. За величиною інтегрального показника безпеки при вживанні контамінованих харчових продуктів (6 балів) спіромезифен належить до 3 класу – помірно небезпечний для людини. Установлено, що обґрунтовані нормативи спіромезифену дають можливість забезпечити безпечність споживання винограду та яблук, вирощених при застосуванні препарату Оберон Рарід 240 SC, КС, а також застосуванні інших пестицидних формуляцій на основі цієї речовини на інших сільськогосподарських культурах.*

Chemical plant protection products account for at least 3% of all biosphere pollutants and are the most studied pollutants on our planet [3]. The main routes of pesticides entry into the human body are the stomach, skin and lungs, and the main sources - food, water and air [3].

The main principles on which risk management is based are the strengthening of educational alternatives to pesticide research; study of data to obtain a more transparent and accessible regulatory mechanism of chemicals; cessation of exports of prohibited plant protection products; support for the reregistration and registration of pesticides in developing countries [13]. It is also worth paying attention to such features of chemicals as the inevitability of their circulation in the biosphere; intended primarily for the fight against harmful living organisms (thus a potential danger to humans and animals); dependence of efficiency on concentration; contact with large masses of the population (people who work with formulations, consumers of food, water, air) [3, 13].

Quite a significant potential risk to public health is the use of food contaminated with residual amounts of active substances of pesticide formulations, which according to literature [9, 10] can cause damage to the liver, endocrine and reproductive systems, adrenal glands, etc.

Therefore, the study, evaluation and analysis of research results of new active ingredients, in our case a new insecticidal compound – spiromesifen, the establishment and substantiation of hygienic standards and

regulations is a priority task that should be controlled at the state level to preserve public health worldwide [9].

The aim of the study was to assess the potential hazard to humans in consumption of apples and grapes treated with an insecticide based on spiromesifen, taking into account scientifically substantiated maximum allowable levels of the compound in these crops.

MATERIALS AND METHODS OF RESEARCH

Spiromesifen is a new insecticidal substance, a representative of the class of tetramic and tetronic acids derivatives with two mechanisms of action: induction of microsomal liver enzymes and inhibition of the enzyme 4-hydroxypyruvate dioxygenase. It is an active ingredient of insecticide formulation Oberon Rapid 240 SC in the amount of 228.6 g/l.

Table 1 shows the main physicochemical properties of spiromesifen [11, 12].

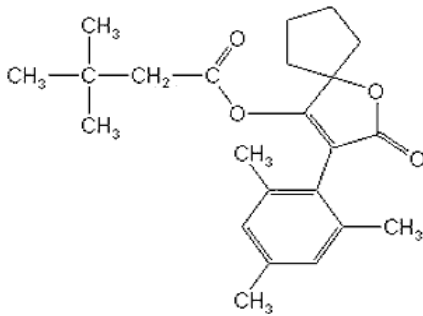
The assessment of the potential hazard to humans when eating foods that may contain spiromesifen residues was performed in several stages. In the first stage, the content of spiromesifen according to [5, 6] in apples and grapes was determined. Samples of the studied cultures were taken and delivered to the laboratory in accordance with [8].

Conditions and locations of Oberon Rapid 240 SC application are shown in Table 2.

The limit of quantitative determination (LOQ) of spiromesifen in apples is 0.01 mg/kg, in grapes – 0.01 mg/kg, the limit of detection (LOD) is 0.004 mg/kg according to [5, 6].

Table 1

Physicochemical properties, stability and toxicity indices of spiromesifen

Index	Spiromesifen
Empirical formula	$C_{23}H_{30}O_4$
Relative molecular weight	370.48
Vapour pressure (at 25°C), mPa	7×10^{-3}
Melting point, °C	98 °C
Solubility in water (at 20 °C), mg/dm ³	0.13
Log K_{ow}	4.55
Structure formula	
Solubility in organic solvents, g/dm ³	heptane – 23, acetone, xylene, ethylacetate – 250
Half-life period in plants (τ_{50}), day	4.1
Allowable daily dose (ADD), mg/kg	0.02

Firstly, determination of organoleptic properties (appearance, size, color, odor, shape) of products [7] grown using the Oberon Rapid 240 SC were made. Comparative evaluation was performed with control samples of products on which the formulation was not used.

The next step was to assess the risk to humans based on a comparison of the allowable daily intake

(ADI) of the compound with food (70% of the total ADI) with the maximum possible daily intake (maximum allowable level (MAL)) × maximum consumption) [7].

At the final stage, the integral hazard index of pesticide-contaminated products consumption was calculated and assessed [1, 14].

Table 2

Conditions and locations of Oberon Rapid 240 SC use

Site No	Crop	Application rate, l/h, multiplicity	Application dates	Application locations
1	Apple tree (Aidared)	0.8 l/h, twice	29.07.2016; 12.08.2016	LLC "Agro Firm "Kolos", Pustovarivka, Skvyra district, Kyiv region
2	Apple tree (Aidared)	0.8 l/h, twice	09.06.2016; 23.06.2016	LLC "Agro Firm "Kolos", Pustovarivka, Skvyra district, Kyiv region
3	Apple tree (Golden Delicious)	0.8 l/h, twice	29.07.2017; 18.08.2017	Ukrainian scientific-research station on plant quarantine of Institute of plant protection of National Academy of Agrarian Sciences of Ukraine, Boiany, Novoselytskyi district, Chernivtsi region
4	Wineyards ("Sukholimansky white")	0.8 l/h, twice	19.05.2016, 27.05.2016	OJSC "Peremoha", Ovidiopol district, Odessa region
5	Wineyards ("Sukholimansky white")	0.8 l/h, twice	29.05.2017, 08.06.2017	OJSC " Peremoha ", Ovidiopol district, Odessa region.

The significance of the discrepancies (testing the hypothesis of equality of the mean two independent samples) was assessed by Student's t-test or non-parametric criteria in the case of differences in the distribution of law from normal. Statistical processing of the results was performed using the licensed statistical software package IBM SPSS Statistics Base v.22.

RESULTS AND DISCUSSION

To substantiate the MAL of spiromesifen we were guided by the basic principles [4], namely: the daily amount of a substance that can enter the body with food, water and atmospheric air which should not exceed the allowable daily dose (ADD) for humans; limiting criteria of toxicological properties of insecticide and changes in organoleptic characteristics of the product.

The ADD value of spiromesifen was established and substantiated in previous studies [2] at the level of 0.02 mg/kg of body weight per day. Based on this, the allowable daily intake (ADI) of the compound for a person weighing 60 kg will be:

$$ADI = 0.0260 = 1.2 \text{ mg/day}$$

Based on the principle of complex hygienic regulation of pesticides, it is known that the human body with food, being the main source of pesticides, can receive up to 70% from ADI of spiromesifen, i.e. 0.84 mg/kg.

According to [7] it was found that the organoleptic properties (size, shape, texture, odor, color, appearance, taste) of grown grapes, apples using the Oberon Rapid 240 SC and freshly made juice (without cooking) did not differ from similar control samples obtained without the use of the formulation.

The results of determining the content of spiromesifen in samples of apples and grapes (average results of 3 determinations) are shown in Table 3.

According to the data in Table 3, during the vegetation season the content of spiromesifen gradually decreased and up to day 28 was 0.008 mg/kg, and in subsequent follow-up and until harvest it did not exceed the limit of detection of the substance (<0.004 mg/kg). The obtained results on determining a residual amounts of spiromesifen in apples allowed to substantiate its MAL at a level of 0.02 mg/kg (limit of quantitative determination of high-performance liquid chromatography (HPLC) – 0.02 mg/kg); apple juice – 0.01 mg/kg (limit of quantitative determination of HPLC – 0.01 mg/kg).

Analysis of the data presented in Table 3 showed that the content of spiromesifen during the vegetation season of the culture gradually decreased and on the 50th day after the last treatment did not exceed the limit of quantification of the method. By the time of

harvest, the content of spiromesifen in grapes and freshly squeezed grape juice was not detected.

The obtained results on the content of residual amounts of spiromesifen in grapes allowed substantiating its MAL in grapes at the level of 0.02 mg/kg (limit of quantitative determination of HPLC – 0.02 mg/kg); grape juice – 0.01 mg/kg (limit of

quantitative determination of HPLC – 0.01 mg/kg). The data shown in Table 3 for the determination of residual amounts of spiromesifen in apples are associated with the early processing of apple orchards and vineyards and allow us to conclude about a fairly rapid degradation of the insecticide in these crops.

Table 3

Content of spiromesifen in apples and grapes (fruits)

Day after last treatment	Content, mg/kg	Day after last treatment	Content, mg/kg
Apples		Grapes	
Day of treatment	0.08±0.01	3	0.15±0.02 – leaves
7	0.05±0.01	14	0.11±0.02 – leaves
21	0.022±0.004	28	0.17±0.002 – little green berries
		49	n.d. – berries
28	0.008±0.001	50	<0.004 – berries
28 (harvest)	n.d. – apples n.d. – juice	62	n.d. – berries
62 (harvest)	n.d. – apples n.d. – juice	75 (harvest)	n.d. – berries n.d. – juice
90 (harvest)	n.d. – apples n.d. – juice	88 (harvest)	n.d. – berries n.d. – juice

Notes: 1. n.d. – not detected at limit of spiromesifen detection in apples and apple juice – 0.004 mg/kg, grapes and grape juice – 0.004 mg/kg; 2. – spiromesifen was not detected in control samples.

To assess the risk of consumption of apples and grapes, the calculation of the possible actual intake of spiromesifen in the human body was performed based on the proposed values of the standards. It was found that the actual intake of spiromesifen (with an average daily consumption of fruit 0.125 kg) with apples and grapes can be 0.0065 mg, and it does not exceed 0.5% of ADI, or 0.7% of the estimated allowable amount of spiromesifen, which can come from food.

Therefore, substantiated spiromesifen MAL make it possible to ensure the safe consumption of grown grapes and apples using Oberon Rapid 240 SC.

According to the value of the integral index of hazard when consuming contaminated food (6 points) spiromesifen belongs to class 3 – moderately dangerous to humans. This is primarily due to the rapid destruction of the insecticide in crops and the rather high value of ADD of the compound, which characterizes it as a low-toxicologically dangerous substance.

CONCLUSIONS

1. Based on the results of the study on the effect of spiromesifen on organoleptic properties, taking into account the data on the toxicity of the compound, and determining the residual amounts of insecticide in apples and grapes, maximum allowable levels of

spiromesifen was substantiated in fruits of these crops at a level 0.02 mg/kg, in apple and grape juices – 0.01 mg/kg.

2. By the results of calculations, according to field studies, the actual intake of spiromesifen with food does not exceed 0.5% of allowable daily dose, or 0.7% of the estimated allowable amount that can enter the human body.

3. The value of an integral index of hazard when consuming insecticide-contaminated apples and grapes allows to pertain spiromesifen to the 3rd class of hazard – moderately hazardous.

Contributors:

Tkachenko I.V. – conceptualization, methodology, investigation, writing – original draft;

Antonenko A.M. – methodology, formal analysis, writing – review & editing;

Bardov V.G. – supervision, project administration;

Omelchuk S.T. – resources, project administration.

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REFERENCES

1. Antonenko AM, Vavrinevych OP, Omelchuk ST, Korshun MM. [Hygienic substantiation of the model for predicting the danger to humans when using agricultural products contaminated with pesticides (on the example of fungicides of the pyrazolecarboxamide class)]. The unity of science. Venna, Avstriia; 2018 Aug:46-8. Ukrainian.
2. Antonenko AM. [Peculiarities of toxicodynamics and hazard assessment of a new insecticide spiromesifen]. Yednist nauky. Venna, Avstriia. 2019:57-8. Ukrainian.
3. [The importance of regulated use of pesticides to ensure the safety of finished products]. Syngenta [Internet]. 2019 Feb [cited 23 Sept 2021]. Ukrainian. Available from: <https://www.syngenta.ua/news/novini-kompaniyi/vazhlivist-reglamentovanogo-zastosuvannya-pestycidiv-dlya-garantuvannya>
4. [State Standard 8.8.1.002-98. State sanitary norms and rules. Hygienic classification of pesticides by degree of danger. Approved by the Ministry of Health of Ukraine 28 Aug 1998]. Kyiv; 1998. 20 p. Ukrainian.
5. [Guidelines for the determination of spiromesifen in apples and apple juice by high performance liquid chromatography No. 1560-2018. Approved Ministry of Ecology and Natural Resources of Ukraine. Order No. 246 dated 06 Jul 2018 and agreed with the State Service of Ukraine for Food Safety and Consumer Protection (No. 7/1173-18 dated 22 May 2018 and No. 87/2594-18 dated 13 Apr 2018)]. (2018). Ukrainian.
6. [Guidelines for the determination of spiromesifen in grapes and grape juice by high performance liquid chromatography No. 1561-2018. Approved Ministry of Ecology and Natural Resources of Ukraine. Order No. 246 dated 06 Jul 2018 and agreed with the State Service of Ukraine for Food Safety and Consumer Protection (No. 7/1173-18 dated 22 May 2018 and No. 87/2594-18 dated 13 Apr 2018)]. (2018). Ukrainian.
7. [Guidelines on hygienic assessment of new pesticides. MU No. 4263-87]. Kyiv; 1988. 210 p. Russian.
8. [Unified Rules for Sampling Agricultural Products, Food Products and Environmental Objects to Determine Micro Amounts of Pesticides. Guidelines. Approved Ministry of Health of the USSR 21 Aug 1997 (1979), No. 2051-79]. (1997). Russian.
9. Shenashen MA, Ayman ES, Emran YM, et al. Progress in sensory devices of pesticides, pathogens, coronavirus, and chemical additives and hazards in food assessment: Food safety concerns. Progress in Materials Science. 2021:100866. doi: <https://doi.org/10.1016/j.pmatsci.2021.100866>
10. Eliseev YY, Spirin VF, Chechomov SY, Eliseeva JuV. Potential health risk associated with consumption of local food containing pesticide residues for the rural population. Gigiena i Sanitariia. 2021;100(5):482-8. doi: <https://doi.org/10.47470/0016-9900-2021-100-5-482-488>
11. PPDB: Pesticide Properties DataBase. Spiromesifen. [Internet]. 2002 [cited 23 Sept 2021]. Available from: <http://sitem.herts.ac.uk/aeru/ppdb/en/Reports/598.htm>
12. Spiromesifen. EU Pesticides database. [Internet]. [cited 2021 Sep 23]. Available from: <https://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/active-substances/index.cfm?event=as.details>
13. The use of pesticides in developing countries and their impact on health and the right to food. Policy Department for External Relations Directorate General for External Policies of the Union PE 653.622; 2021. 56 p.
14. Vavrinevych OP, Antonenko AM, Omelchuk ST. Hygiene assessment of fungicides on human health influence risk after consumption of agricultural products grown in their application. Dovkillia i zdorovia. 2018;1(85):58-63. doi: <https://doi.org/10.32402/dovkil2018.01.058>

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