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EXPERT STUDIES OF THE QUALITY OF PICKLED BIOFORTIFIED TOMATOES IN TERMS OF SAFETY INDICATORS

An expert study of the quality of pickled biofortified tomatoes was conducted according to safety indicators (content of toxic elements - lead, cadmium, arsenic, mercury; nitrate content; content of pesticide residues; content of aflatoxin B1 and patulin). Tomatoes for processing are grown using innovative technologies of agronomic biofortification. Organic fertilizer "Riverm" was used, which provides a natural increase in the content of vitamins and minerals in vegetables. The results of the study revealed that the content of toxic elements in the test sample does not exceed acceptable levels. Nitrates are 2.5 times less than allowed for this type of food. The content of pesticides in the prototypes of pickled tomatoes is less than the sensitivity limit of the method used for the study. In the studied samples of pickled biofortified tomatoes the content of mycotoxins does not exceed the permissible levels. Based on the results of expert research, a conclusion was made - the product samples meet the requirements of regulatory documents and are safe for consumers.

Keywords: pickled tomatoes, agronomic biofortification, expert research,"Riverm", toxic metals, mycotoxins, pesticides

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ЕКСПЕРТНІ ДОСЛІДЖЕННЯ ЯКОСТІ МАРИНОВАНИХ БІОФОРТИФІКОВАНИХ ТОМАТІВ ЗА ПОКАЗНИКАМИ БЕЗПЕКИ

Проведено експертне дослідження якості маринованих біофортифікованих томатів за показниками безпеки (вмістом токсичних елементів - свинцю, кадмію, миш'яку, ртуті; вмістом нітратів; вмістом залишків пестицидів; вмістом афлатоксину В1 та патуліну). Томати для переробки вирощували з використанням інноваційних технологій агрономічної біофортифікації, яка являэ собою цілеспрямоване використання спеціальних мінеральних добрив для збільшення концентрації мікро- і макронутрієнтів в їстівних частинах сільськогосподарських культур. Використовували органічне добриво «Ріверм», яке забезпечує природне збільшення вмісту вітамінів та мінералів в овочах і не має негативного впливу на ґрунт. Методи дослідження: фізико-хімічні: спектрофотометричні, хроматографічні (високоефективна рідинна хроматографія (ВЕРХ) та тонкошарова хроматографія (ТШХ), фізичні (вольтамперометрія). Результати дослідження показали, що вміст токсичних елементів у досліджуваному зразку не перевищує допустимих рівнів. Зокрема, вміст свинцю в маринованих помідорах у 12 разів нижчий за допустимі рівні, миш'яку – у 3 рази. Нітратів у 2,5 рази менше за допустимий для цього виду харчових продуктів. Вміст пестицидів у дослідних зразках маринованих помідорів менший за межу чутливості методу, що використовувався для дослідження. У дослідних зразках маринованих біофортифікованих томатів вміст мікотоксинів не перевищує допустимих рівнів: патуліну – менше 0,01 мг/кг, афлатоксину В1 – менше 0,001 мг/кг. За результатом експертних досліджень зроблено висновок - зразки продукції відповідають вимогам нормативних документів і є безпечними для споживачів.

Ключові слова: мариновані помідори, агрономічна біофортифікація, експертні дослідження, "Ріверм", токсичні метали, мікотоксини, пестициди.

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STATEMENT OF THE PROBLEM

Expert research on the quality of new food products is a complex process that consists of evaluating the properties of new products to determine compliance with standards and regulatory requirements, as well as assessing consumer properties and determining safety indicators.Agronomic biofortification is the purposeful use of special mineral fertilizers to increase the concentration of micro- and macronutrients in the edible parts of crops. Existing fertilizers are added to the soil or treated with plant leaves during growth and development. This technology allows you to grow crops enriched with important minerals and vitamins: iron, zinc, selenium, iodine, copper, carotene, folate. These compounds are the cause of micronutrient starvation of most of the world's population [12]. When using fertilizers for bio-enrichment of vegetables with macro- and microelements, they are strictly required - they should not be a source of compounds harmful to human health. Biofertilizers increase the iron content in lentils [8], get rice

enriched with iron, boron and amino acids [6]; grow biologically valuable in terms of iron and zinc wheat and corn [9]. Using fertilizers recommended for organic farming, get valuable selenium peas [1] and cassava [11]. Applying fertilizers to the soil, which include iodine and selenium, increases these micronutrients in broccoli and carrots grown in greenhouses [18]; potato tubers and pea seeds [5]; basil leaves, cilantro, onions [13]; cauliflower heads [17]; tomatoes [15]. Special fertilizers significantly increase the content of bioavailable iodine [2] and calcium [14] in lettuce leaves.

ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

Agronomic biofortification, as a modern, innovative technology for growing crop products, promotes the maximum accumulation of biologically valuable compounds in the grown products. But agronomic biofortification techniques used in agriculture should not cause contamination of crops with harmful substances of chemical and biological origin - heavy metals, pesticides, radionuclides, mycotoxins, etc. This is very important both when bio-enriched vegetables are used fresh and when consumers are offered long-term processing products. The main thing is full compliance with the requirements of national and international legislation on regulated safety indicators.

According to the HACCP food management system, the main hazards are biological, chemical and physical factors. Biological factors are the most essential for human health, but chemical hazards have the greatest cumulative effect. That is, why the control of toxic compounds (dangerous metals, pesticides, nitrates, mycotoxins) that enter the body with food is very essential.

Lead and cadmium are among the most dangerous metals in humans. The main sources of their income to food - hazardous waste from many industrial enterprises, gasoline combustion products, some pesticides [25]. Lead can cause kidney damage and hypertension in adults. Lead is especially dangerous for children, its toxic effects cause disorders in the development of the brain and nervous system. The toxicity of cadmium exceeds the harmful effects of lead. It accumulates rapidly in the kidneys and liver, and is excreted very slowly, sometimes for several decades. Excess cadmium in the human body adversely affects the metabolism of iron and calcium, as well as is the cause of complex poisoning and dangerous diseases [21].

Mercury has a pronounced toxic effect on the nervous, digestive and immune systems; affects the normal functioning of the lungs, kidneys, skin and eyes. The most dangerous mercury and methylmercury for pregnant women, they have a teratogenic effect [22]. Arsenic is used in crop production with contaminated water used for irrigation and industrial waste. Excessive amounts can lead to chronic poisoning, which over time manifests itself in various skin lesions and causes skin cancer [24].

Nitrates are added to fresh vegetables and fruits with contaminated water and excessive mineral fertilizers. The most harmful nitrates for babies. Contaminated water used for cooking can cause methemoglobinemia [20].

Uncontrolled use of pesticides to control pests and weeds in agriculture accumulates them in the soil. Therefore, crop products grown in such soils can be very dangerous for humans. Pesticides are characterized by acute toxicity and bioaccumulation. According to Ukrainian legislation, aldicarb, aldrin, 2,4-D amine salt, dinitroorthocresol, heptachlor, validotion, parathion methyl are not allowed in food products; pyrazophos; metaphos, thiram, chlorthaldimethyl and other pesticides [19].

Mycotoxins are produced by fungi, the nutrient medium for which is crop products. Mold appears both during harvesting and during storage in humid and warm rooms. Mycotoxins are chemically and thermally stable compounds. Their content is not reduced during the processing of fresh fruits and vegetables in high and low temperatures. Several hundred mycotoxins have been identified, but several are particularly toxic to humans, including aflatoxin B_1 and patulin. Their effect on humans is manifested during the consumption of affected vegetables, fruits, cereals, nuts. If contaminated feed is used to feed animals, dairy and meat products can be a source of mycotoxins. Aflatoxin is a product of mold fungi. *Aspergillus flavus Aspergillus parasitscus,* found in soil, hay, etc. Large doses of aflatoxin, which enter the human body once, can cause acute poisoning - aflatoxicosis. This mycotoxin is considered genotoxic, it can damage DNA and cause cancer in experimental animals. Patulin is produced by the fungi *Aspergillus, Penicillium and Byssochlamys*. Acute patulin poisoning is manifested by damage to the liver, kidneys, spleen, as well as negative effects on the immune system [23].

HIGHLIGHTING PREVIOUSLY UNRESOLVED PARTS OF THE OVERALL PROBLEM

Ukrainian organic fertilizer “Riverm” differs from fertilizers used in the world in its multi-vector nature: it increases soil fertility, improves the marketable properties of plant products grown on these soils [7; 10; 16]. Advantages of “Riverm”: contains a large amount of nutrients (nitrogen, phosphorus, potassium, magnesium, iron, boron, copper, manganese, molybdenum, zinc, etc.), as well as living microorganisms; does not contain synthetic components that guarantee its full safety for plants, animals, people; demineralizes heavy and saline soils, increases their fertility; promotes the formation of biologically active compounds (vitamins, amino acids, etc.) in plants, which improve their growth and development [3; 4; 26]. Vegetables grown using it have properties that distinguish them from those grown under traditional conditions

FORMULATION OF THE ARTICLE'S GOALS (TASK STATEMENT)

Goal - expert study of pickled biofortified tomatoes according to safety indicator.

Scientific novelty: consists in studying the safety indicators (content of heavy metals, nitrates, pesticides and mycotoxins) of pickled biofortified tomatoes as innovative food products.

PRESENTATION OF THE MAIN RESEARCH MATERIAL

Material and methods

Sample. pickled biofortified tomatoes. Vegetables grown with "Riverm" organic fertilizer were used for their production. The method of production of canned vegetables included sorting, washing, preparation of tomatoes and additional raw materials, preparation of marinade filling, packaging, sealing, sterilization. To prepare 100 kg of marinade, 80% acetic acid was used - 1.42 kg, salt - 4.0 kg, sugar - 2.86 kg, extract - 2.56 kg, water - 89.16 kg. The mixture of spices from which the water extract was prepared to include (per 1000 kg of canned food): cinnamon - 0.3 kg, cloves - 0.2 kg, allspice - 0.2 kg bitter pepper (red or black) - 0.16 kg, bay leaf - 0.4 kg.To the mixture of spices provided by the recipe, from which the aqueous extract was prepared, ginger root was additionally introduced in the amount of 0.15-0.2 kg (per 1000 kg of canned food); the pH of the marinade filling was 2.8-3.0.

Laboratory methods: physico-chemical: spectrophotometric, chromatographic (high performance liquid chromatography (HPLC) and thin layer chromatography (TLC), physical (voltammetry. The method is based on previous mineralization of sample of the product, getting mineralized solution with the addition of background electrolyte, conducting analysis in the electrolyser, obtaining current-voltage curves and measuring the height of the peaks).

Results and discussion

In the experimental samples of pickled tomatoes, safety indicators were determined: the concentration of toxic elements - lead, cadmium, arsenic, mercury; nitrate content; residual pesticides; mycotoxin content. Table 1 shows the results of studies on the content of toxic compounds - lead, cadmium, mercury, arsenic and nitrates in pickled tomatoes, biofortified by applying the organic fertilizer "Riverm".

Tab. 1 shows the results of studies on the content of toxic compounds - lead, cadmium, mercury, arsenic and nitrates in pickled tomatoes, biofortified by applying the organic fertilizer "Riverm".

Table 1

The content of toxic elements in pickled biofortified tomatoes, mg/kg

Indicator	Permissible levels, no more	Fact	Error, %
Lead	0,50	0,0359	± 15
Cadmium	0,03	0,0101	± 15
Mercury	0,02	< 0, 003*	± 20
Arsenic	0,20	0,0690	± 30
Nitrates	150,0	61,3	± 30

* the sensitivity limit of the method

The content of toxic elements in the test sample does not exceed the permissible levels (Table 1). In particular, the amount of lead in pickled tomatoes is 12 times less than the permissible levels, arsenic - 3 times, nitrates - 2.5 times. The cadmium content is 0.0101 mg/kg, which does not exceed the permissible level of0.03 mg/kg. Mercury contains less than 0.003 (permissible level - 0.02 mg/kg).

Content of pesticides. Table 2 shows the results of determining the residual amount of pesticides in the prototypes of pickled biofortified tomatoes.

Table 2

Residual amount of pesticides in pickled biofortified tomatoes, mg/kg

Name of pesticides	Permissible levels, no more	Fact
DDT (sum of metabolites)	0,1	< 0, 005*
Heptachlor	is not allowed	< 0, 005*
Carbophos	0,5	< 0, 02*
Metaphos	is not allowed	< 0, 004*
Phosphamide	0,4	< 0, 02*
Dursban	0,05	< 0, 02*
2,4-D	is not allowed	< 0, 0004*
Ripcord	0,2	< 0, 01*
Ambush (permethrin)	0,4	< 0, 01*
Decis	0,01	< 0, 01*
Actelic	0,2	< 0, 004*
Basudin	0,5	< 0,004*
Aldrin	is not allowed	< 0, 005*

* the sensitivity limit of the method

The presence of such pesticides as heptachlor, metaphos, 2,4-D, aldrin is not allowed in food products (Table 2). The content of these pesticides in the prototypes of pickled tomatoes is less than the sensitivity limit of the method used for the study. Samples of pickled tomatoes contain less than 0.005 mg/kg of DDT and its metabolites at acceptable levels up to 0.1 mg/kg; carbophos - less than 0.02 mg/kg (permissible content - up to 0.5 mg / kg),

phosphamide - less than 0.02 mg / kg (permissible level - up to 0.04 mg/kg). Foodstuffs should contain, no more than, mg/kg: dursban 0.05, ripcard 0.2, ambush 0.4, decis 0.01, actelic 0.2, basudin 0.5. In the experimental samples of pickled tomatoes were found, respectively, less than mg/kg: dursban 0.02, ripcard 0.01, ambush 0.01, decis - 0.01, actelic 0.004, basudin 0.004. Therefore, pesticides were found in pickled biofortified tomatoes in quantities not exceeding the permissible levels or in quantities less than the sensitivity limit of the method used for the research.

Content of mycotoxins.

The content of mycotoxins of patulin and aflatoxin B_1 was determined in experimental samples of pickled tomatoes (table 3).

Table 3.

The content of mycotoxins in pickled biofortified tomatoes, mg/kg

Indicator	Permissible levels, no more	Fact
Patulin	0,05	< 0,01*
Aflatoxin B_1	0,005	< 0,001*

* the sensitivity limit of the method

According to the regulations in force in Ukraine, the content of patulin in food should not exceed 0.05 mg/kg, and the content of aflatoxin B_1 - not more than 0.005 mg/kg. In the studied samples of pickled biofortified tomatoes the content of mycotoxins does not exceed the permissible levels: patulin - less than 0.01 mg/kg, aflatoxin B1 - less than 0.001 mg/kg.

CONCLUSION

Based on the results of expert studies of pickled biofortified tomatoes for safety indicators - the content of heavy metals (lead, cadmium, arsenic, mercury); nitrates; residual pesticides; the content of mycotoxins (patulin and aflatoxin B1), it was concluded that the test samples meet the requirements of regulatory documents. Therefore, the use of Riverm fertilizer did not lead to exceeding the permissible levels of toxic compounds in the products of processing biofortified vegetables.

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