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Not peer-reviewed version

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Posted Date: 12 March 2025

doi: 10.20944/preprints202503.0863.v1

Keywords: food safety; apricot safety; agricultural commodity safety; fresh fruits safety regulations

 doi:10.20944/preprints202503.0863.v1

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Evaluation Safety of Fresh Apricot

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Abstract: The problem of food safety is extremely relevant, due to the general characteristics of the modern world, such as environmental pollution and urbanization. Apricots are an important fresh fruit and nutritionally valuable for humans, as they are rich in polyphenols, vitamins and carotenoids. The purpose of this paper is to present food safety, factors affecting FFs safety, legislation and indicators that should be study for determination of FFs safety according to the regulations and researches carried out up to this moment. The main objective of this study is safety evaluation of some apricot varieties, cultivated in Bulgaria. The methods applied are: determination of lead and cadmium in FFs - inductively coupled plasma mass spectrometry (ICP-MS); determination of pesticide residues - gas chromatography (GC) and liquid chromatography (LC) with subsequent extraction/separation with acetonitrile and purification by dispersing SPE-QuEChERS-method; horizontal method for detection, enumeration and serological typing of *Salmonella*; horizontal method for detection and enumeration of *Listeria monocytogenes*, *Enterobacteriacea* and *Clostridium spp.* It was found that lead content is 0,005-0,014 mg/kg, cadmium content is less than 0,005 mg/kg, content of organophosphorus, carbamate and dithiocarbamate pesticides is less than 0,010 mg/kg, content of 288 studied pesticides is below the maximum permissible residue levels. In composition of apricots, were not found *Salmonella species* and *Listeria monocytogenes*, *Enterobacteriaceae* in the varieties Hungarian, Delmast and Roxana is less than 10 CfU/ g, and in variety Silistrenska Compotna is 30 CfU/ g, *Clostridium spp.* is less than 10 CfU/ g for all varieties. As a result, was found that the varieties of fresh apricots are safe, do not pose a risk to consumers health, fruits could be used for further investigations of FFs quality and their intended use for consumption and processing.

Keywords: food safety; apricot safety; agricultural commodity safety; fresh fruits safety regulations

1. Introduction

Apricot (*Prunus Armeniaca*), also known as the *"golden egg of the sun"*, grows in colder and drier temperate climates around the world [1,2]. It is believed that the homeland of this fruit species is Southeast Asia with the center of Northern China. In addition to this region, apricot is widespread in the wild already in eastern Tibet, Alma Ata and Central Asia, and this gives scientists reason to believe that this is another center of its origin [3]. According to a group of researchers, the Japanese apricot (*Prunus mume Sieb. et. Zucc.*), also known as Ume, is used for food and as a medicinal product in East Asian countries [4]. Apricot kernels found during excavations in Armenia, dating back to ancient times, are grounds to believe that Armenia is also one of the centers associated with the origin of this fruit species [5]. This is the reason why the common apricot receives the Latin name Armenica. According to some sources, the traditions associated with the cultivation of apricots in Anatolia date back nearly 2000 years [6].

Later, the apricot was brought to Greece, and from there it spread to other Mediterranean countries and parts of Europe [7,8]. In America, apricot became famous in the XVII-XVIII centuries. It was brought to Africa later, but it is not widespread at this latitude. It is believed that the apricot penetrated into Bulgaria from Greece [9].

 doi:10.20944/preprints202503.0863.v1

Apricots are an important fruit crop and nutritionally valuable for humans. They are fruits of high nutritional value, as they are rich in polyphenols, vitamins and carotenoids. The fruit is consumed fresh or dried, but it is used also to make fruit juices, nectars and preserves [10–12].

Global food security is one of the most important challenges to be considered in order to ensure that the growing demand for quality food is provided to consumers. The problem of food safety is extremely topical because of the common features of the modern world, such as environmental pollution and urbanization. Foods of plant origin are contaminated before they are offered to consumers or processed into food products. Very often, dangerous agents remain unharmed due to their nature.

Safety is considered as a fundamental property of fresh fruit, ensuring that it does not contain harmful substances and FFs does not pose a risk to the health of consumers. FFs contamination can be due to various reasons, most often the pollutants being biological and chemical. FFs in the composition of which pollutants have been found in quantities above the regulated requirements are not allowed to be offered on the EU market. When examining safety of FFs, modern methods are applied to establish the content of: heavy metals, pesticide residues, the regulated microbiological criteria for FFs safety.

Safety of FFs is determined after analyzing the results of biological and chemical risks. *Biological risks* are related to exposure to bacteria, viruses, molds, other micro-organisms and related toxins. They are widespread in nature and pose a potential danger to consumer health. Biological risks have been identified mainly in foods of animal origin and less often in foods of plant origin and in particular in fresh fruits. *Chemical risks* are due to pharmacologically active substances - used to combat diseases and pests in agriculture. A significant part of chemical substances enters the environment as pollutants, and also settle in the composition of some raw materials and food. In the case of fresh fruit, the content of certain contaminants that pose a danger, such as heavy metals and pesticides, is subject to control. Examination and proof of FFs safety, after comparing the compliance of the studied varieties of FF with the regulated requirements for the content of heavy metals (lead and cadmium), pesticides and some microbiological indicators.

Safety of FFs is a priority over all other quality characteristics, therefore, when applying the integrated approach, it is of paramount importance to prove, first of all, that fruits are safe (i.e., they do not contain contaminants in the composition of FF above the regulated, maximum permitted quantities). Safety differs significantly from the quality characteristics of fresh fruits (FFs), since they can be defined as high-quality, but not safe, because they are contaminated with microorganisms and toxic chemical contaminants. At the same time, it is possible that FFs, in which high results for the studied quality indicators have not been established, may be safe. The properties and quality of FFs are the main reason why it is not possible to offer them to consumers and commercialize, while the risks related to the safety of fresh fruits may remain undisclosed by consumers when choosing and subsequently consuming FFs [13–15].

The main objective of the present work is evaluation of the safety of some variety's fresh apricots cultivated in Bulgaria. This would be useful in further investigations of FFs quality and their intended use for consumption and processing. The purpose of the present study is to make a reasoned analysis of food safety and in particular safety of FFs, factors affecting fresh fruit safety, legislation in the field of fresh fruit safety according to the regulations and researches carried out up to this moment. The article is based on a study of a large number of the legislation and literary sources, clarifying the nature of FFs safety, and factors that influence it. After analyses of the results presented by the regulations and the scientists was made a summary of the factors that influence safety of FFs and indicators that should be analyzed for determination of FFs safety. Some apricot varieties are studied and was determined that they are safe and can be offered to consumers or used as a raw material for the processing industry. The accepted thesis is that FFs safety is influenced by specific factors and for its determination FFs should be analyzed according to the methods applied in the regulations and results should be compared with the requirements presented in the regulatory documents.

 doi:10.20944/preprints202503.0863.v1

2. Materials and Methods

The object of this research are some varieties of apricots, the choice is made according to the fact that these are fruit species with traditions in cultivation on the territory of Bulgaria, of great importance for the domestic and foreign markets, and the processing industry. The varieties of apricots (*Prunus armeniaca*) selected and studied for safety are well known and preferred by consumers, they are variety Hungarian, variety Delmas, variety Roxana and variety Silistrenska compotna. The fruits in botanical ripeness from different harvests (with typical size, shape, color and taste properties) were evaluated in the period 2021-2024.

The apricots were examined in the Alimenti-Omnilab Testing Laboratory at D&V CONSULT Ltd., Tsaratsovo village, Plovdiv region, Bulgaria. When evaluating FFs safety the following indicators were determined: content of heavy metals, content of pesticides and the regulated microbiological safety criteria for FFs.

Heavy metals. The content of lead and cadmium in the composition of FFs is regulated and controlled by Regulation 915, 2023 and Regulation 333, 2007 [16,17]. The methods are regulated in BDS EN 15763:2010 and an inductively coupled plasma mass spectrometry (ICP-MS) (BDS EN 15763:2010) is applied.

Pesticides. Pesticides in composition of FFs are residues that have entered the composition or are on the surface of FFs from the preparations used for the treatment of plantations. The maximum residue level (MRL) should be understood as the maximum permitted level of the concentration of pesticide residues in or on FFs. The content of the full package of 288 pesticides in the content of the studied varieties FFs was evaluated, and for this purpose a gas chromatographic method of analysis (BDS EN 15662:2018) was applied.

Microbiological indicators. Microbiological methods are used to determine the microbiota of FFs [18,19]. According to the requirements of Regulation 2073, 2005, the presence of microorganisms, their toxins, metabolites in quantities posing an unacceptable risk to the health of consumers is not allowed in the composition of FFs. For testing are applied the regulated food safety criteria reflected in the Methodological Guideline for National, Microbiological Criteria for Foods Not Subject to Regulations 2073, 2005 and Regulation 1441, 2007: *Salmonella species* (BDS EN ISO 6579-1:2017/A1:2020), *Listeria monocytogene*s (BDS EN ISO 11290-1:2017), and the indicator microorganisms *Enterobacteriaceae* (BDS EN ISO 21528-2:2017) and sulphite-reducing *Clostridium spp.* (ISO 15213-1:2023; BDS EN ISO 15213-1:2023), which characterize the risk of soil contamination of FFs. The methods applied are: horizontal method for detection, enumeration and serological typing of *Salmonella*; horizontal method for detection and enumeration of *Listeria monocytogenes*, *Enterobacteriaceae* and *Clostridium spp*.

3. Results

3.1. Fresh Fruit Safety

The motto of Codex Alimentarius is related to food safety and reads: "safe, good food for all – everywhere". Food safety as defined in ISO 22000:2018 is: "ensuring that food will not cause an adverse effect on the consumer when prepared and consumed according to its intended use". Food safety is also considered as the extent to which the requirements related to a specific characteristic or property that has the potential to be harmful to health or cause illness within the intended shelf life or shelf life and the storage methods indicated. The assurance that a food will not cause an adverse effect on health, including injury or illness, is determined by the absence or reduction to an established acceptable level of the hazards contained therein. The safety of fresh fruit is a priority over all other quality characteristics [20–23].

The problem of food safety is relevant because of the dynamic development of the modern world, environmental pollution and urbanization. Food raw materials of plant origin are contaminated even before they are processed into food products. Very often, dangerous agents go

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unharmed because of their nature. On the other hand, during the production, storage and sale itself, there is again a possibility of contamination, and hence danger. With food products, a significant part of the substances with a harmful effect enters the human body and cause acute or chronic diseases. There are various hazards that can contaminate food products and damage human health [24].

FFs safety is ensured by taking measures the offered FFs are fit for human consumption within the intended use and shelf life. It is important to make difference between the concepts of 'hazard' and 'risk'. Hazards are from a biological, chemical or physical agent with the potential to cause harm. In contrast, risk is an assessment of the likelihood and severity of undesirable effects on consumer health due to hazards (natural components or environmental pollutants) in the composition of fresh fruit. The relationship between reducing the hazards associated with FFs and the risk of adverse health effects for consumers requires the implementation of appropriate controls to ensure their safety [25].

Fresh fruits are classified as low-risk foods (foods with a low risk for foodborne diseases) because they have a cuticle and protective epidermis on the surface with a greater thickness compared to most vegetables, and also a significant part of them is harvested from trees or shrubs. The sources of contamination of FFs are most often soil, fertilizers, irrigation water, animal/poultry wastes, harvesting, processing, distribution, trade and consumption of fresh fruit [26].

3.2. Factors Affecting FFs Safety

Fresh fruits contain minerals, vitamins, fiber, and antioxidants, which are the main components of a healthy diet for humans [27]. The presence and evolution of food safety risks are determined by factors in and outside the chain of food production, market and logistic chain, such as climatic, economic and agricultural. The interactions between these factors and the supply chain are complex and a systematic approach is needed to uncover causal relationships in order to be able to carry out effective actions to minimise risks of FFs safety [28].

Climatic factors include temperature, precipitation, etc. Most of the research on the effect of climate on agriculture has focused on yields [29], production and the risk of famine [30]. Other aspects of climate impacts on the safety of fresh fruit include the consequences for the agricultural sector due to: mycotoxins formed by molds; pesticide residues and persistent pollutants; pathogenic microorganisms [32]; weed growth and potential variations in herbicide efficacy under changing climatic conditions [33].

Economic factors include information related to the product, such as monthly and annual prices, total production, quantities imported annually into Europe, total area per year, general information about the country (annual budget for agriculture, percentage of GDP spent on agriculture, etc.), industrial development, etc. In our country, the sources of pollution with heavy metals of the soil, respectively the plant species are the factories for non-ferrous metals. The toxic heavy metals most frequently identified pollutants in composition of FFs are lead and cadmium [34,35].

Agricultural factors include the use of water for irrigation, pesticides, fertilisers, herbicides, insecticides, fungicides and rodenticides [36,37]. The water used in agriculture is considered as a factor that affects the risk of microbiological contamination of FFs, for example: the type of water source, the method of irrigation (drip irrigation, sprinkling, etc.), contact of the edible part of the FFs with the irrigation water, etc. Water sources and the quality of water used for irrigation have an impact on the microbiological contamination of FFs. Water with poor quality may be the cause of the spread of localized pollution of plantations. It has been proven that when water is in direct contact with the product, its quality affects the contamination of FFs with pathogens. When pathogens on the product survive, they can cause foodborne illness. The pathogens most often transmitted through low-quality water are intestinal bacteria - Salmonella spp., Listeria monocytogenes, Campylobacter spp.; certain strains of E. coli (VTEC); viruses, cano Norovirus [38]. In order to improve the quality of water for irrigation of plantations, producers use broad-spectrum disinfectants against pathogenic bacteria and demonstrate positive results in achieving a reduction in the identified microorganisms in the composition of the water used for irrigation [39]. In order to improve the efficiency and

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quality of production, pesticides are used during the following stages - planting, harvesting and storage, therefore, it is possible to establish different concentrations of pesticide residues in the composition of FFs [40,41].

Although there are processes in the industry that can reduce pesticide residues. In the case of FFs, post-processing processes are not applied before they are exported to the commercial network and offered to consumers, therefore it is possible that they contain pesticide residues in their composition. Therefore, it is believed that through the consumption of FFs, pesticides enter the human body [42].

Pesticides that are most commonly used to treat perennials include organophosphates, organochlores, and carbamates [43,44]. Control over pesticide residues in food is carried out on various goods of plant origin, offered in the commercial network. It has been found that most often the pollution is from representatives of some groups of pesticides (organophosphorus, carbamate and dithiocarbamate), and the responsibility is on the farmers. The maximum levels of pesticide residues in foodstuffs and FFs are reflected in Regulations and a Directive of the European Union [45]. At present, the main perspective that can be applied is the use of biopesticides, through which an increase in the production of FFs can be achieved without compromising the health of consumers. Biopesticides are derived from natural materials (plant, animal, bacterial or minerals) and are used to control various pests, including insects, pathogens and weeds. Biopesticides are safe for humans and the environment, they are of lower toxicity, targeting a specific pest or several pests [46].

Based on the above, it should be summarized that the most important factors that can be related to production of safe FFs with desirable and expected by consumers properties are: the influence of climatic conditions on the average annual yields of FFs, the development of industry in agricultural areas, the quality of water used for irrigation of plantations, the number of chemical substances, used for processing and fertilizing perennials.

3.3. Legislation of Fresh Fruits Safety

The availability of safe food is a fundamental human right proclaimed by the United Nations. The European Union puts this problem in the spotlight and develops for this purpose Regulations, Directives and Decisions of Brussels, which are the basis of the national policies of the Member States [47]. Currently, there is a significant regulatory base related to food safety, which is constantly updated and adapted as new developments emerge. This legislation is based on risk analysis in food and feed production, food processing, storage, transport and sales, imports and exports. The basic principles of food safety are presented at Regulation 178/2002, which requires businesses to ensure that all foods, food additives and food /feed for animals can be certified backwards in the food chain that they are safe for consumers. Good contaminants are chemical, biological, physical or radiological in nature. Their safety should be considered in the following areas: chemical safety, biological safety, physical safety and radiological safety [48].

The main risks which appeared at FFs are biological and chemical.

Biological risks (biofood safety). Biological risks to consumer health are related to exposure to bacteria, viruses, molds, other micro-organisms and related toxins. These microorganisms are widespread in nature and pose a potential health hazard to consumers. Biological risks exist in food, especially in products of animal origin.

Chemical risks (chemical food safety). Chemical risks are food additives in the composition of foods, pharmacologically active substances used to combat diseases and pests in agriculture. A significant part of chemical substances enters the environment as pollutants, and also settle in the composition of some raw materials and food. In this regard, an EU Regulation (REACH) has been developed aimed at improving the protection of human health and the environment from the risks that can be caused by chemical substances, as well as regulating the registration, evaluation and authorisation of their use [49–51].

The changes that have taken place in Bulgaria related to the economy, market mechanisms and food trade require compliance of national and international requirements and standards. Therefore,

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an update of the regulatory framework has been made, and the basic principles of the current European law in the field of food safety have been introduced into the national legislation [52]. After Bulgaria's accession to the EU, a Methodological Guide was developed, which reflects the Bulgarian national microbiological criteria for food products. The methodology of microbiological regulation and the basic principles reflected in Regulation 2073, 2005, Codex Alimentarius, etc. are used. [53–55] and the microbiological safety criteria that are applied throughout the food chain in our country are presented.

3.3.1. Legal Framework in the Field of Fresh Fruit Safety

The legal framework in the field of FFs safety is examined by presenting national regulations and EU policies (Table 1). The Food Act is a major national document defining the requirements for food safety, business operators, working in food production, processing and/or distribution facilities. The Food Act defines the requirements that are valid for each stage of food production and aims to ensure the application of EU law and national measures related in this area [56].

Table 1. Legal framework in the field of food safety.

№	Politics	Source
National legislation		
1.	Legal provisions on food safety	[23]
2.	State policy on regarding food safety	[57]
Union legislation		
1.	EU food safety policies	[58]
		[59]
2.	EU food hygiene policies (hygiene package)	[60]
3.	EU policies on maximum levels for certain contaminants in food	[61]
		[62]
International legislation		
1.	International Production and Food Safety Policies	[63]

Source: Own research.

The Agri-Food Chain Management Act regulates the state policy on safety, consumer protection, contaminants in food, and in particular pesticide residues in them. The implementation of safe FFs on the market and the prevention of their impact on consumer health are approaches set back in 2004 by the European Union when introducing the so-called Safe Products, New Approach legislation. The existing legislation until the accession of the Republic of Bulgaria as a member of the European Union has been revised, and since 2007 new acts of the Union have been mandatory for application [64–66].

With the publication of Regulation 178, 2002, called the European Food Act, the European Union created a new legal framework that sets out principles to ensure a consistent approach and the promotion of principles, obligations and definitions related to food security. The Regulation provides food safety requirements, according to which a specific product should not be offered to consumers, if it is not safe. A particular food is considered unsafe if it is: harmful to the health of consumers; unfit for human consumption [67]. In order to establish equivalent systems of official controls on food and feed in all Member States, the European Commission is introducing a harmonized system of common rules at Community level governing such controls [68].

Safety of FFs is determined on the basis of some microbiological criteria, the content of heavy metals and pesticides. Microbiological hazards in the composition of foods are a major source of some foodborne diseases in humans. Therefore, the composition of food products, and in particular FFs, is

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not allowed to contain microorganisms (their toxins or metabolites) in quantities that pose an unacceptable risk to human health [69].

The main provisions and requirements of Regulation 852, 2004 are reduced to: the responsible persons for food safety; the need to ensure food safety throughout the food chain; the guidelines for good practice as a tool to support food business operators at all levels of the food chain; the establishment of microbiological criteria and requirements for temperature control based on risk assessment. In accordance with Article 4 of Regulation 852, 2004 Food producers and traders must comply with microbiological criteria. Measures to be taken by food producers and traders include controlling raw materials, hygiene, temperature and shelf life of the product. Obtaining a safe product in food production is leading for producers and traders, and is a major commitment in terms of achieving compliance with these requirements. The content of Regulation 1317, 2021 presents the maximum levels of lead in the composition of certain foods, and Regulation 915, 2023 reflects the maximum levels of certain contaminants (mycotoxins, heavy metals, plant toxins, processing contaminants, halogen persistent organic pollutants and other contaminants – melamine, nitrates, perchlorate) in the composition of food.

In conclusion, it should be summarized that there are national, European and international regulations and policies outlining the legal framework in the field of food safety and in particular for FFs. Over the years, it is constantly evolving and updated, so it is necessary to keep stakeholders well informed with the latest updates in order to offer consumers safe FFs.

3.3.2. Regulatory Requirements for FFs Safety

Fresh fruits are low-risk foods, as they are covered with cuticle and have a thick, protective epidermis different from that of vegetables, and they are also harvested from trees or shrubs. It has also been proven that a significant part of microorganisms is not able to continue their vital activity in the composition of fruits, and the reason for this is the low pH of the environment. Contamination of fruits can occur at different stages of their growth, sources of contamination are soil, natural fertilizers, irrigation water, etc., during harvesting, processing, logistics, storage and use of FFs for its intended purpose processing, distribution, trade [70] and consumption.

The regulatory requirements for safety of FFs have been regulated over the years in national standards and regulations, but at the moment Regulations with precisely defined requirements have been developed and are in force. Their content reflects requirements related to biological hazards, content of heavy metals and pesticides. Regulation 1441 reflects the microbiological criteria for food, presenting the criteria and requirements for biosafety of food, criteria for technological hygiene and the preparation of test samples [71]. Regulation 333 presents the methods for sampling and analysis of heavy metals in food formulations. The requirements for maximum levels for certain contaminants, including lead and cadmium in the composition of FFs, are set out in Regulation 915 [72,73]. Regulation 396, 2005 lays down principles, the need to ensure consumer protection and provisions on pesticide residues in food and feed [74].

At present, the requirements for FFs safety are regulated in national and Union legislation (Table 1). There are other documents that present the methods used to study safety indicators of FFs, such as: the content of heavy metals, certain microorganisms and pesticides.

FFs traders, in modern conditions, require their suppliers to prove the compliance of products with independently verifiable standards. Such a standard is Global G.A.P., recognized by the Global Food Safety Initiative and ranks among the norms relating to voluntary certification such as: IFS Food (International Standard for Conformity Assessment of Products and Processes with regard to Food Safety and Quality), BRC (BRC Standard Certification by Third-Party Audit gives assurance to customers and partners about the quality and safety of food products), FSSC 22000 (Food Safety Standard under the Global Food Safety Initiative - GFSI) and others, ensuring safe production of raw materials and food. The principles set out in the international standard are based on sustainable agriculture with minimal impact on the plant protection products used, with the aim of limiting residues in the produced FFs. Through the application of the rules, in accordance with the

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requirements of the Global G.A.P standard, it is ensured that agricultural products are from certified producers, processed in a way that is safe for consumer health and environmental protection [75]. The standard is divided into modules for the different productions, such as: fresh fruits and vegetables, crops for processing, production of planting material and others. The individual chapters of the standard reflect requirements for planting material, soil management, irrigation and fertigation, harvesting and processing of production. The system generates reports and is supported by traders, manufacturers, suppliers and retail chains.

As a result of the studies on the requirements, it can be summarized that during the analysis of the regulatory documents related to FFs safety, there are documents presenting the methodology and requirements for certain controlled biological and chemical contaminants posing a risk to the health of consumers. The submitted contaminants should be controlled when establishing FFs safety, before being offered commercially to consumers and their use as raw materials in the processing industry.

3.4. Evaluation of Apricots Safety

Consumption of fresh apricots has increased significantly in recent years, apricot Market Size was estimated at 16.81 (USD Billion) in 2024 and is expected to be around 4.3% during the period (2025-2034) [76], and the main reason for this is the benefits which they have for the health of consumers, but due to the presence of contaminants they can also cause some diseases transmitted to humans through food. Therefore, monitoring the residues of heavy metals, pesticides and pathogenic microorganisms in the composition of FFs is a serious problem, as they can have a significant impact on safety of apricots and the health of consumers. FFs safety is determined after evaluation of the following indicators: content of heavy metals, content of pesticides and the regulated microbiological criteria for FFs safety.

3.4.1. Evaluation of Heavy Metals in Composition of Some Apricot Varieties

Heavy metals and their salts found in foods belong to the group of chemical pollutants, also called environmental pollutants. Some of them, such as lead, cadmium, and mercury, are toxic [77,78]. Heavy metals have been found to be absorbed by plant roots and accumulate in high concentrations in the edible parts of plants, thus posing a serious risk to the health of consumers. They pass into the composition of plant species and, in particular, fresh fruits from the soil and water of areas contaminated with industrial waste. The intake of heavy metals with food poses a serious risk to the health of consumers. Lead and cadmium have been shown to have carcinogenic effects, and high concentrations in the composition of fresh fruits have been associated with the widespread prevalence of gastrointestinal cancer. This requires strict control and monitoring of fresh fruits offered to consumers for heavy metal content. In the composition of some varieties of peaches, nectarines and apricots, the content of lead and cadmium has been studied.

It was found that lead content in composition of the studied apricot varieties was below the regulated MAQs. In apricots, the lead content is highest in the studied variety "Hungarian" and lowest in the variety "Delmast". In the composition of the studied apricot varieties, it was found that the cadmium content is below the regulated MAQs. In the fruit varieties studied, it is less than 0,005 mg/kg (Table 2). The results of the studies were compared with the regulated maximum levels reflected in Regulation 915 and in the Standard set by the World Health Organization, Food and Agriculture Organization. It was found that the content of the tested heavy metals (lead and cadmium) in the composition of some apricots varieties is below the limit of the maximum allowed, regulated quantities in General Standard for Contaminants and Toxins in Food and Feed, 1995 and Regulation 915, 2023. In conclusion, it can be summarized that the content of lead and cadmium in the composition of the studied apricot varieties are in safe quantities for consumers. Therefore, the studied FFs varieties are safe.

Table 2. Heavy metal content in composition of some apricot's varieties.

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№	Indicators	Requirements according to Regulation EU 2023/915, Maximum allowable quantity (MAQ)	Varieties/ Results			
			variety "Hungarian"	variety "Delmast"	variety "Roxana"	variety "Silistrenska Compotna"
1.	Lead content, mg/kg	0,10	0,014	0,005	0,006	0,006
2.	Cadmium content, mg/kg	0,050	< 0,005	< 0,005	< 0,005	< 0,005

Source: Own research.

3.4.2. Evaluation of Pesticides in Composition of Some Apricot's Varieties

Pesticides are specific substances designed to protect and reduce the impact of pests on cultivated plant species. crops from damage and to combat insects and rodents. Inadequate application of pesticides in agriculture seriously threatens and affects public health and the environment [79]. Pesticides have been found to be biologically active substances that can cause various effects on human health. It has been proven that the consumption of contaminated FFs with organophosphorus and methylcarbamate compounds has an impact on the nervous system, cause cancer, heart disease, and others irritate the skin and mucous membranes of a person. In most cases, the amounts of pesticide residues in and on food are negligible to cause an adverse effect on consumer health [80].

The increasing use of pesticides in agriculture is the reason for the development of legislation for their sale and use, the main goal being to protect the market from the spread of chemical substances with unacceptable properties. A system has been established in the EU to approve pesticides and control their use. Within the framework of this approval, companies requesting marketing authorization for a product must prove that the product containing the pesticide residues is safe and does not pose a risk to the health of the consumer [81]. Pesticide residues are quantifiable from the active substances used as plant protection products, as they are found in the composition of the harvested crop of plant origin or in food of animal origin in Regulation 396, 2005 [82].

The main principles outlined in European legislation are protection of consumer health and production of safe food [83]. Pesticides pollute the environment, food, and have been shown to have a negative impact on human and animal health. In the processing of agricultural products, pesticides are applied in allowed, permissible and effective doses, but some of them remain in the plants during harvest in the form of residues. Because of this fact, the levels of the amounts found in food must be safe. As a member of the EU, our country is obliged to ensure compliance and control of the maximum residue levels, which are the highest standardized level of pesticide residues in the composition of food and feed. The fulfillment of these requirements is a prerequisite for obtaining quality food and raw materials of plant origin, increased competitiveness and access of products to international markets. The main applicable tool for ensuring food safety at the moment is the so-called. risk assessment, the credibility of which is based entirely on adequate scientific research and data [83,84]. This necessitates the implementation of studies on the content of pesticide residues in the composition of some varieties of apricots.

A quantitative analysis of 288 compounds belonging to the different groups of pesticides in the composition of some varieties of apricots was carried out, and the results obtained for each of them

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were compared with the requirements and it was found that the studied FFs complied with the regulated requirements (Appendix A1).

Results for the most important groups of pesticide compounds (organophosphorus, carbamate and dithiocarbamate pesticides) studied in the composition of some varieties of apricots are presented. In the composition of the studied varieties of apricots (Table 3), it was found that the content of organophosphorus, carbamate and dithiocarbamate pesticides was below the MRLs. The obtained results prove that the studied fruits are safe. The results of the studies confirmed that the content of 288 compounds belonging to the different groups of pesticides in the studied FFs varieties was below the level of the maximum permissible residue levels of pesticides. This is evidence that the varieties of apricots subject to this study are safe, not contaminated with pesticides, therefore consumers are protected from the adverse effects of pesticide residues on their health.

Table 3. Pesticide content in composition of some apricot's varieties.

№	Indicators	Requirements according to [86], Maximum residue levels	Varieties/ Results			
			variety "Hungarian"	variety "Delmast"	variety "Roxana"	variety "Silistrenska Compotna"
1.	Content of organophosphate pesticides, in mg/kg	0,01	<0, 010	<0, 010	<0, 010	<0, 010
2.	Carbamate pesticide content, in mg/kg	0,01	<0, 010	<0, 010	<0, 010	<0, 010
3.	Content of dithiocarbamate pesticides, in mg/kg	2.0	<0, 010	<0, 010	<0, 010	<0, 010

Source: Own research.

3.4.3. Evaluation of Microbiological Criteria for FFs in Composition of Some Apricot's Varieties

The microbiology of nutrition is an independent area of food hygiene, and the leading among the biological hazards in food are various types of bacteria, some of which are pathogenic, others carrying potential pathogenicity, but also sources of toxic substances and various enzymes involved in the processes of spoilage. Biological risks to human health are related to exposure to bacteria, viruses, molds, other microorganisms and related toxins. These microorganisms are common in nature and pose a potential health hazard to consumers. Microbiological hazards exist in the external environment, in raw materials and food. The risk to the final consumer arises from consuming food contaminated primarily or secondarily with microorganisms. In primary contamination, raw materials contain pathogens or conditionally pathogenic microorganisms that have not been destroyed during processing and thus end up in the final product. In case of secondary contamination, it is possible to get microorganisms in case of non-compliance with sanitary and hygienic requirements by the staff, uncleaned machines, equipment, packaging, etc.

Microorganisms that cause plant diseases and in particular fresh fruits are not pathogenic to humans, so plant raw materials are contaminated with microorganisms dangerous to humans from the external environment, and the sources are most often the water with which the plantations are watered, the soil, the harvesting personnel, the presence of industrial waste, etc. A number of factors related to the use of water in agriculture affect the risk of microbiological contamination of FFs, most often these are: the water source, the type of irrigation (drip irrigation, sprinkling, etc.), the direct contact of the edible part of the FFs with the irrigation water, the application of water purification

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methods, irrigation immediately before harvesting, possible access of animals to the water source, etc.

In agricultural practices, water sources and the quality of water used before harvesting, during harvest and after harvest are different, all of which have different impacts on microbiological contamination of FFs. Water of unsatisfactory quality has been shown to be a source of pollution and the cause of the spread of localized contamination in the field, in the facilities or during transport. When water comes into contact with products, its quality has an impact on the possibility of contamination by FFs pathogens. If the pathogens on the product survive, they can cause foodborne illnesses, most of which are carried through low-quality water (contaminated water) are intestinal bacteria, for example, *Salmonella spp*., *Listeria monocytogenes*, etc.

People are a serious source of contamination of foods of plant origin during harvesting in the presence of acute infectious disease, inflammation of the hands and nasopharynx, carrier of infection, etc. In case of non-compliance with good hygiene practices and lack of hygiene habits, the staff poses a risk in terms of the safety of food of plant origin during their collection, sorting and processing. Production waste, in case of untimely removal and storage in the enterprise, is a source of food contamination, therefore, in production companies, the crossing of the paths of raw materials, ready-made foods and waste should not be allowed [87].

In the case of fresh fruits intended for direct consumption, the safety criteria are *Salmonella species* and *Listeria monocytogenes*, and among the indicator microorganisms, an important place is occupied by sulfite-reducing *Clostridium spp.* and *Enterobacteria*, through which the risk of soil contamination of FFs is characterized [88,89].

Fresh fruits are defined as low-risk foods because they have a thick protective epidermis on which the cuticle is located, compared to fresh vegetables and are harvested (harvested) mainly from trees or shrubs. FFs contamination can occur during the development and ripening of fruits (due to contaminated soil, use of natural fertilizers, irrigation water, animal/poultry waste), harvesting, processing (including washing), distribution, trade and consumption. It has been found that a large part of the microbial pathogens does not survive on the fruit, and this is explained by the low pH of FFs. In the composition of fresh fruits, bacterial pathogens (*Salmonella, L. monocytogenes*) are controlled, which pose a danger to the health of consumers. Salmonella is the most common foodborne pathogen, affecting millions of people a year, sometimes with severe and fatal results. Infection with *Listeria* leads to unplanned abortions in pregnant women or death of newborns. The incidence of diseases is relatively low, severe and sometimes fatal health consequences (infants, children and the elderly) rank them among the most serious foodborne infections. Foodborne diseases are most often infectious or toxic in nature and are caused by bacteria, viruses or parasites entering the human body through contaminated food or water. Foodborne pathogens can cause severe disorders or infections, including meningitis, etc.

Table 4 presents the results of the studied microbiological safety criteria for some varieties of apricots. Based on the results of the studies carried out, the eligibility for consumption of the batch of fresh fruit placed on the market is determined. In composition of the studied varieties apricots, were not found *Salmonella species* and *Listeria monocytogenes*. Content of indicator microorganisms (*Enterobacteriaceae* and *Clostridium spp.*), characterizing the risk of soil contamination of FFs, are below the levels of the regulated requirements (Table 4). Therefore, the studied varieties of apricots are safe. The results obtained from the conducted studies confirm that the composition of the studied varieties of FFs does not contain bacterial pathogens, and the content of indicator microorganisms is below the levels of the regulated requirements. Therefore, the studied FFs varieties are safe, not contaminated and do not pose a risk to the health of consumers.

Table 4. Results of microbiological criteria in composition of some apricot's varieties.

№	Indicators	Requirements	Varieties/ Results			
			variety	variety	variety	variety

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			"Hungarian"	"Delmast"	"Roxana"	"Silistrenska Compotna"
1.	*Salmonella species*	not to settle in 25 g	not established	not established	not established	not established
2.	*Listeria monocytogenes*	not to settle in 25 g	not established	not established	not established	not established
3.	*Enterobacteriaceae, CfU/ g*	< 1000	< 10	< 10	< 10	30
4.	*Clostridium spp., CfU/ g*	< 100	< 10	< 10	< 10	< 10

Source: Own research.

The presented article shows that in the studied area of FFs safety, there are a lot of researchers who study and analyze different problems connected foods, but there are not found research works presented complex analyses of FFs safety, regulation towards them and evaluation of FFs safety. That's why the results and their analyses in the area of FFs safety is of great importance and should be considered when studying FFs safety which will be offered to consumers, used in the processing sector as a raw material for production of preserves, for freezing, for drying and for export.

The results obtained in this study showed that in terms of FFs safety, the determined indicators are content of lead and cadmium, pesticide residues and some microbiological safety criteria for FFs (*Salmonella species*, *Listeria monocytogenes*, *Enterobacteriaceae* and *Clostridium spp.*). It was found that lead content in the composition of the studied apricot varieties was below the regulated MRLs. In apricots, the lead content is 0,005-0,014 mg/kg, the highest content was found in the studied variety "Hungarian" - 0,014 mg/kg and the lowest in the variety "Delmast" – 0,005 mg/kg. In the composition of the studied apricot varieties, it was found that the cadmium content is below the regulated MRLs. It was found that in the studied fruit varieties, the content of cadmium is less than 0,005 mg/kg. The content of organophosphorus, carbamate and dithiocarbamate pesticides was below the MRLs in composition of the studied apricots varieties, it is less than 0,010 mg/kg. The results of the studies confirmed that the content of 288 compounds belonging to the different groups of pesticides in the studied FFs varieties was below the level of the maximum permissible residue levels of pesticides. In composition of the studied varieties apricots, were not found *Salmonella species* and *Listeria monocytogenes*. Content of indicator microorganisms (*Enterobacteriaceae* and *Clostridium spp.*), characterizing the risk of soil contamination of FFs, are below the levels of the regulated requirements. Content of *Enterobacteriaceae* in the varieties Hungarian, Delmast and Roxana is less than 10 CfU/ g, and in variety Silistrenska Compotna is 30 CfU/ g. Content of *Clostridium spp.*, is less than 10 CfU/ g. This is evidence that the varieties of apricots subject to this study are safe, not contaminated with heavy metals, pesticides, bacterial pathogens and indicator microorganisms. Therefore, the studied FFs varieties are safe, not contaminated and do not pose a risk to the health of consumers.

The results of this study could be used in further investigations of FFs quality and opportunities for their use as a product offered to consumers and as a raw material for processing industry.

4. Conclusions

The studies made, the analysis of the data and the results of the scientific studies carried out related to FFs safety, factors affecting FFs safety, legislation in the field of FFs safety, evaluation of apricot safety give us the following important conclusions and generalizations:

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- The factors that can be related to the production of save FFs with desirable and expected properties by consumers are: the influence of climatic conditions on the average annual yield of FFs, the development of industry in agricultural areas, the quality of water used for irrigation of plantations, the number of chemical substances used for processing and fertilizing perennial crops.
- There are national, European and international regulations and policies outlining the legal framework in the field of food safety, and in particular FFs. Over the years, it has been constantly evolving and updated, so it is necessary to keep stakeholders well informed with the latest updates in order to offer consumers and processors safe FFs.
- At present, the requirements for FFs safety are regulated in national and Union legislation. There are other documents that present the methods that should be used and apply when investigating safety of FFs, such as: content of heavy metals, detection of certain microorganisms, content of pesticides.
- After analyses of the results presented by the regulations and the scientists was made a summary of the factors that influence FFs safety and the indicators that should be analyzed for determination of their safety.
- As a result of the studies of the regulatory requirements, it can be summarized that after the analysis of the regulatory documents related to FFs safety, there are documents presenting the methodology and requirements for certain controlled biological and chemical pollutants posing a risk to the health of consumers that should be observed. The submitted contaminants should be controlled when establishing FFs safety before they are commercially available to consumers and their use as raw materials in the processing industry.
- The content of lead and cadmium in the composition of the studied varieties apricots is below the limit of the maximum allowable regulated quantities;
- The content of 288 compounds belonging to the different groups of pesticides in the studied FFs varieties are below the regulated levels of the maximum allowable residue levels of pesticides;
- No bacterial pathogens were found in the composition of the studied varieties of apricots, and the content of indicator microorganisms (sulfite-reducing *Clostridia* and *Enterobacteria*), characterizing the risk of soil contamination of fresh fruits, was below the levels of the regulated requirements.
- It was found, through the carried evaluation of some apricot varieties, that:
- content of lead and cadmium, pesticide residues and some microbiological safety criteria for FFs in composition of the studied varieties of apricots was below or in the levels of the regulated requirements;
- safety of fresh fruits has been proven, i.e., the studied fruit varieties are not contaminated with heavy metals (lead and cadmium), pesticides, pathogenic microorganisms and indicator microorganisms, therefore through the carried-out evaluation was proven that they are safe and do not pose a risk to the health of consumers.

Funding: This research received no external funding.

Conflicts of Interest: The author declares no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

BRC	Standard Certification by Third-Party Audit gives assurance to customers and partners about the quality and safety of food products
CfU	Colony forming Unites
FFs	Fresh Fruits
G.A.P.	Good Agricultural Practice
GC	Gas chromatography
GFSI	Global Food Safety Initiative

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EU	European Union
ICP-MS	Inductively coupled plasma mass spectrometry
IFS	International Standard for Conformity Assessment of Products and Processes with regard to Food Safety and Quality
LC	Liquid chromatography
MAQ	Maximum allowable quantity
MRL	Maximum residue level
REACH	Registration, Evaluation, Authorization and Restriction of Chemicals
SPE	Solid Phase Extraction
VTEC	Verotoxigenic *Escherichia coli*

Appendix A

Table A1. Pesticides in composition of the studied apricots varieties
Supplementary data

References

1. Leccese, A.; Bartolini, S.; Viti, R. Total antioxidant capacity and phenolics content in apricot fruits. *International Journal of Fruit Science* ***2007***, *7(2)*, pp. 3-16.
2. Hacıseferoğulları, H.; Gezer, İ.; Özcan, M.; MuratAsma, B. Post-Harvest Chemical and Physical–Mechanical Properties of Some Apricot Varieties Cultivated in Turkey. *J. Food Eng.* ***2007***, *79*, pp. 364–373.
3. Ali, M.; Mehdi, M.; Lakdan, S.; Dolkar, T.; Stanzen, L.; Singh, P.; Hussain, S. Status of area and production of apricot (*Prunus armeniaca L.*) in Cold Arid Ladakh. *Journal of Pharmacognosy and Phytochemistry* ***2018***, *7(2)*, pp. 93-595.
4. Horinishi, A.; Toyama, Y.; Watanabe, M.; Ayano, S.; Ozaki, Y. Changes in Proanthocyanidin Content during the Processing of Umeshu, a Spirit-Based Liqueur of Japanese Apricot (*Prunus mume Sieb. et Zucc.*) Fruit. *ACS Food Science & Technology* ***2022***, *2 (10)*, pp. 1565-1573, DOI: 10.1021/acsfoodscitech.2c00208
5. Donev, S. *The Orchard*, Publisher: Kolkhida, Bulgaria, 2015; pp. 304 (pp. 141-149).
6. Asma, B. *Apricot Culture in the Historical Process*, Publisher: Uyum Ajans, Turkey; 2015, pp. 281.
7. Malinov, V. *Apricot production*, Publisher: Vasilina, Bulgaria, 2003, pp. 31.
8. Khadari, B.; Krichen, L.; Lambert, P.; Marrakchi, M.; Audergon, J. Genetic Structure in Tunisian Apricot, *Prunus Armeniaca L.*, Populations Propagated by Grafting: A Signature of Bottleneck Effects and Ancient Propagation by Seedlings. Genet. *Resour. Crop Evol.* ***2006***, *53*, pp. 811–819.
9. Manganaris, G.; Crisosto, C. Chapter 15.1 - Stone fruits: Peaches, nectarines, plums, apricots. In *Controlled and Modified Atmospheres for Fresh and Fresh-Cut Produce*, Editor(s): Maria Isabel Gil, Randolph Beaudry; Publisher: Academic Press, 2020, pp. 311-322, https://doi.org/10.1016/B978-0-12-804599-2.00017-X.
10. Moustafa, K.; Cross, J. Production, Pomological and Nutraceutical Properties of Apricot. *J. Food Sci. Technol.*, ***2019***, *56*, pp. 12–23.
11. Dragovic-Uzelac, V.; Levaj, B.; Mrkic, V.; Bursac, D.; Boras, M. The Content of Polyphenols and Carotenoids in Three Apricot Cultivars Depending on Stage of Maturity and Geographical Region. *Food Chem.*, ***2007***, *102, 3,* pp. 966–975, https://doi.org/10.1016/j.foodchem.2006.04.001.
12. Taylor, M. *Vegetables and Fruits. Nutritional and Therapeutic Values*. Publisher: CRC Press/Taylor and Francis Group, USA, 2008, pp. 286, doi:10.1017/S0014479708007333
13. Gupta, C.; Prakash, D. Chapter 10 - Safety of Fresh Fruits and Vegetables. In *Food Safety and Human Health*; Editor(s): Ram Lakhan Singh, Sukanta Mondal, Publisher: Academic Press, 2019; pp. 249-283, https://doi.org/10.1016/B978-0-12-816333-7.00010-2.
14. Yonkova, G.; Kechev; M., Arabska, E. *Food quality and safety – veterinary medical requirements for the use of drugs, pesticides, heavy metals and aflatoxins*; Publisher: Blakom, Bulgaria, 2011; pp. 24.
15. Paraskova, P.; Damyanova, E. Food quality and safety. *New knowledge*, ***2012***, *3*, pp. 50-54.
16. Stoyanov, S. *Heavy metals in the environment and food products*. Publisher: Pensoft, Bulgaria, 1999; pp. 288.
17. Bekyarov, G. *Heavy metals – their impact on health, sources of pollution and non-clinical methods for their determination in the human body. Expert opinion*. Publisher: IKP, Bulgaria; 2009, pp. 47.

 doi:10.20944/preprints202503.0863.v1

18. Jay, J.; Loessner, M.; Golden, D. *Modern food microbiology*, 7th Edition, Publisher: Springer, USA, 2005; pp. 753.
19. Zagrai, L.; Zagrai, I. Chapter 80 - Temperate fruits-II Tree fruits (apricot, peach, plum), In *Viral Diseases of Field and Horticultural Crops*; Editor: L.P. Awasthi; Publisher: Academic Press, 2024; pp. 701-712, https://doi.org/10.1016/B978-0-323-90899-3.00006-9.
20. Codex Alimentarius. Available online: http://www.fao.org/fao-who-codexalimentarius/about-codex/en/#c453333 (accessed on 11 November 2024)
21. ISO 22000:2018/Amd 1:2024 Food safety management systems Requirements for any organization in the food chain Amendment 1: Climate action changes. Available online: https://www.iso.org/files/live/sites/isoorg/files/news/magazine/ISOupdate/EN/2024/ISOupdate%20March%202024.pdf (accessed on 19 November 2024)
22. Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety. Available online: https://eur-lex.europa.eu/legal-content/bg/TXT/?uri=CELEX%3A32002R0178 (accessed on 16 November 2024)
23. Food Act. Available online: https://www.mzh.government.bg/bg/normativni-aktove/zakoni/ (accessed on 01 December 2024)
24. Paraskova, P.; Damyanova, E. Food quality and safety. *New knowledge*, ***2012***, *3*, pp. 50-54.
25. Gyurova, D. Food composition and safety – interrelationship, importance and priority for public health. *Bulgarian Journal of Public Health* ***2021***, *13 (3)*, pp. 89-98.
26. Khalil, R.; ElLeithy, A.; Ayoup, M.; Abu-Saied, M.; Sharaby, M. Zein-based nisin-loaded electrospun nanofibers as active packaging mats for control of Listeria monocytogenes on peach. *Food Chemistry* ***2024***, *459*, 140441, https://doi.org/10.1016/j.foodchem.2024.140441
27. Kaparapu, J.; Pragada, P.; Geddada, M. Fruits and Vegetables and its Nutritional Benefits. In *Functional Foods and Nutraceuticals*; Egbuna, C., Dable Tupas, G., Eds.; Publisher Springer, Cham., 2020, https://doi.org/10.1007/978-3-030-42319-3_14
28. Mileva, L. Big Data Predictions of Seasonal Fluctuations in Marine Traffic (using AIS data) by Monitoring Idle Ships. *Business & Management Compass* ***2024***, *68 (4)*, pp. 5-22. DOI: 10.56065/f0wzb375
29. Kaparapu, J.; Pragada, P.; Geddada, M. Fruits and Vegetables and its Nutritional Benefits. In *Functional Foods and Nutraceuticals*; Egbuna, C., Dable Tupas, G., Eds.; Publisher Springer, Cham., 2020, https://doi.org/10.1007/978-3-030-42319-3_14
30. Lobell, D.; Field, C.; Cahill, K.; Bonfils, C. Impacts of future climate change on California perennial crop yields: Model projections with climate and crop uncertainties, *Agricultural and Forest Meteorology* ***2006***, *141 (2–4)*, pp. 208-218.
31. Parry, M.; Rosenzweig, C.; Iglesias, A.; Livermore, M.; Fischer, G. Effects of climate change on global food production under SRES emissions and socio-economic scenarios. *Global Environmental Change* ***2004***, *14 (1)*, pp. 53-67.
32. Miraglia, M.; Marvin, H.; Kleter, G.; Battilani, P.; Brera, C.; Coni, E.; Cubadda, F.; Croci, L.; Santis, B.; Dekkers, S.; Filippi, L.; Hutjes, R.; Noordam, M.; Pisante, M.; Piva, G.; Prandini, A.; Toti, L.; van den Born, G.; Vespermann, A. Climate change and food safety: An emerging issue with special focus on Europe. *Food and Chemical Toxicology* ***2009***, *47, (5)*, pp. 1009-1021, https://doi.org/10.1016/j.fct.2009.02.005.
33. Varanasi, A.; Prasad, P.; Jugulam, M. Impact of climate change factors on weeds and herbicide efficacy. In *Advances in agronomy*; Donald, L., Eds.; Publisher: Academic Press, 2016; 135, pp. 107-146.
34. Petrova, S.; Altunkova, S.; Cherkezova, S.; Gavrailova, M.; Mikushinska, N.; Nikolova, N.; Vachkova, R.; Georgiev, G.; Georgieva, R.; Vasilevski, N.; Popivanova, A.; Ivanova, L.; Baykova, D.; Angelova, K.; Duleva, V.; Ovcharova, D.; Vatralova, K.; Yordanov, B.; Enikova, R.; Kirov, K.; Ganev, V.; Gogov, Y.; Kostov, I.; Hristov, B.; Badurin, V.; Yordanova, E.; Adil, G. *National Action Plan Food and Nutrition*; Publisher: Council of Ministers, Bulgaria, 2004; pp. 84.
35. Bogoeva, I. Pesticides in food – toxicity and health risks. Pesticide regulation. MAF; Publisher: Centre for Food Chain Risk Assessment, Bulgaria, 2023; pp. 19.

 doi:10.20944/preprints202503.0863.v1

36. Official Journal of the European Union. Commission Notice on Guidance on the management of microbiological risks in fresh fruit and vegetables at primary production through good hygiene (2017/C 163/01). Available online: https://eur-lex.europa.eu/legal-content/BG/TXT/?uri=uriserv%3AOJ.C_.2017.163.01.0001.01.BUL&toc=OJ%3AC%3A2017%3A163%3AFULL (accessed on 17 November 2024).
37. Bouzembrak, Y.; Marvin, H. Impact of drivers of change, including climatic factors, on the occurrence of chemical food safety hazards in fruits and vegetables: A Bayesian Network approach. *Food Control* ***2019***, *97*, pp. 67-76, https://doi.org/10.1016/j.foodcont.2018.10.021
38. Avila-Novoa, M.; Solis-Velazquez, O.; Guerrero-Medina, P.; Martínez-Chávez, L.; Martínez-Gonzáles, N.; Gutiérrez-Lomelí, M. *Listeria monocytogenes* in Fruits and Vegetables: Antimicrobial Resistance, Biofilm, and Genomic Insights. *Antibiotics*, ***2024***, *13 (11):1039*. https://doi.org/10.3390/antibiotics13111039
39. Van Blair, J.; Lacombe, A.; Harvey, B.; Wu, V. Chlorine dioxide is a broad-spectrum disinfectant against Shiga toxin-producing *Escherichia coli* and *Listeria monocytogenes* in agricultural water. *Front. Microbiol* ***2024***, *15:1469615*. doi: 10.3389/fmicb.2024.1469615
40. Philippe, V.; Neveen, A.; Marwa, A.; Basel, A. Occurrence of pesticide residues in fruits and vegetables for the Eastern Mediterranean Region and potential impact on public health, *Food Control* ***2021***, *119*, https://doi.org/10.1016/j.foodcont.2020.107457
41. Ahmadi, S.; Khazaei, S.; Mehri, F. Determination of pesticide residues in fruits: a systematic review and meta-analyses, *Journal of Food Composition and Analysis* ***2024***, *128*, https://doi.org/10.1016/j.jfca.2024.106012
42. Topping, C.; Aldrich, A.; Berny, P. Overhaul environmental risk assessment for pesticides. *Science* ***2020***, *367*, pp. 360-363. doi:10.1126/science.aay1144
43. Sharma, A.; Shukla, A.; Attri, K.; Kumar, M.; Kumar, P.; Suttee, A.; Singh, G.; Barnwal, R.; Singla, N. Global trends in pesticides: A looming threat and viable alternatives. *Ecotoxicology and Environmental Safety* ***2020***, *201*, https://doi.org/10.1016/j.ecoenv.2020.110812
44. Centanni, M.; Ricci, G.; Girolamo, A.; Romano, G.; Gentile, F. A review of modelling pesticides in freshwaters: Current status, progress achieved and desirable improvements. *Environmental Pollution* ***2023***, *316 (2)*, https://doi.org/10.1016/j.envpol.2022.120553
45. Regulation (EC) No 396/2005 of the European Parliament and of the Council of 23 February 2005 on maximum residue levels of pesticides in and on food or feed of plant or animal origin and amending Council Directive 91/414/EEC (Text with EEA relevance) (OJ L 70, 16.3.2005, p. 1). Available online: https://eur-lex.europa.eu/legal-content/BG/TXT/PDF/?uri=CELEX:02005R0396-20080410&from=LV (available on 05 September 2024).
46. Adejumo, T.; Vogele, R. *Biopesticides: Botanicals and Microorganisms for Improving Agriculture and Human Health*; Publisher: Logos Verlag, Germany, 2021; pp. 290.
47. Enikova, R. Biological food safety and health policy in this area. *Social Medicine* ***2019***, *3*, pp. 2-9.
48. Stefanova, M. Changes in the Food Law. *Law and Business in Modern Society* ***2020***; pp. 236-241.
49. Yonkova, G.; Kechev; M., Arabska, E. *Food quality and safety – veterinary medical requirements for the use of drugs, pesticides, heavy metals and aflatoxins*; Publisher: Blakom, Bulgaria, 2011; pp. 24.
50. European Chemical Agency. Available online: https://echa.europa.eu/bg/regulations/reach/understanding-reach (accessed on 11 December 2024).
51. Pashova, S. Contemporary Aspects of Goods` Safety. *Izvestia Journal of the Union of Scientists - Varna. Economic Sciences Series* ***2021***; *10 (1)*, pp. 80-89.
52. Petrova, S.; Altunkova, S.; Cherkezova, S.; Gavrailova, M.; Mikushinska, N.; Nikolova, N.; Vachkova, R.; Georgiev, G.; Georgieva, R.; Vasilevski, N.; Popivanova, A.; Ivanova, L.; Baykova, D.; Angelova, K.; Duleva, V.; Ovcharova, D.; Vatralova, K.; Yordanov, B.; Enikova, R.; Kirov, K.; Ganev, V.; Gogov, Y.; Kostov, I.; Hristov, B.; Badurin, V.; Yordanova, E.; Adil, G. *National Action Plan Food and Nutrition*; Publisher: Council of Ministers, Bulgaria, 2004; pp. 84.
53. Regulation (EC) 2073/2005 of 15 November 2005 on microbiological criteria for foodstuffs (Text with EEA relevance). Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32005R2073 (accessed on 9 December 2024).

 doi:10.20944/preprints202503.0863.v1

54. Enikova, R. *Bulgarian National Criteria for Microbiological Food Safety. Opinion*; Publisher: National Centre for Public Health Protection (NCPPH), Bulgaria, 2009; pp. 47.
55. Enikova, R. Regulations 2073/2005 and 1441/2007 of the European Union on microbiological criteria for foodstuffs. Guidelines for practical application; Publisher: National Centre for Public Health Protection (NCPPH), Sofia, 2008; pp. 41.
56. Stefanova, M. Changes in the Food Law. *Law and Business in Modern Society* ***2020***, pp. 236-241.
57. Agri-Food Chain Management Act. Available online: https://bfsa.egov.bg/wps/wcm/connect/bfsa.egov.bg19113/babba1f7-e5d9-4064-804e-f646fb6f60d7/zakon_za_upravlenie_na_agrohranitelnata_veriga.pdf?MOD=AJPERES&CVID=oai2cu1 (accessed on 01 July 2024).
58. Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety. Available online: https://eur-lex.europa.eu/legal-content/bg/TXT/?uri=CELEX%3A32002R0178 (accessed on 16 November 2024).
59. Regulation (EU) No 625/2017 of the European Parliament and of the Council of 15 March 2017 on official controls and other official activities performed to ensure the application of food and feed law, animal health and animal welfare rules, plant health and plant protection products. Available online: https://eur-lex.europa.eu/legal-content/BG/TXT/?uri=celex%3A32017R0625 (accessed on 17 December 2024).
60. Regulation (EC) No 852/2004 of the European Parliament and of the Council on the hygiene of foodstuffs (OJ L 139, 30.4.2004, p. 1). Available online: https://eur-lex.europa.eu/legal-content/BG/TXT/?uri=CELEX%3A02004R0852-20090420 (accessed on 01 November 2024).
61. Regulation (EU) 1317/2021 of 9 August 2021 amending Regulation (EC) No 1881/2006 as regards maximum levels of lead in certain foodstuffs. Available online: https://eur-lex.europa.eu/legal-content/BG/TXT/?uri=uriserv%3AOJ.L_.2021.286.01.0001.01.BUL&toc=OJ%3AL%3A2021%3A286%3AFULL (accessed on 09 December 2024).
62. Regulation (EU) 915/2023 on maximum levels for certain contaminants in food. https://eur-lex.europa.eu/BG/legal-content/summary/maximum-levels-for-certain-contaminants-in-food.html (accessed on 07 December 2024).
63. Codex Alimentarius. Available online: http://www.fao.org/fao-who-codexalimentarius/about-codex/en/#c453333 (accessed on 11 November 2024).
64. Stoyanova, A. Regulatory framework for risk assurance in the food chain. *Law and business in modern society: Proceedings of the 2nd National Scientific Conference* ***2019***, pp. 380-390
65. Stefanova, M. Approaches for determining quality. *Quality and control of goods in conditions of COVID pandemic. Proceedings of conference organized by the Centre for Goods Quality and Consumer Protection* ***2021***, pp. 110–116. Available online: https://ue-varna.bg/uploads/filemanager/303/publishing-complex/2021/Kachestvo-kontrol-stoki-Covid-2021.pdf (accessed on 11 November 2024).
66. Stefanova, M. Options for Prevention of Product Cross-Contamination in Logistic Processes. *International Journal of Innovative Science and Research Technology* ***2021***, *6*, pp. 1162–1166. Available online: https://ijisrt.com/assets/upload/files/IJISRT21JUL1198.pdf (accessed on 22 November 2024).
67. Tabanova, M.; Stratev, D.; Pashov, T. *Food Safety*. Publisher: MES, Bulgaria, 2021; pp. 258.
68. Regulation (EU) No 625/2017 of the European Parliament and of the Council of 15 March 2017 on official controls and other official activities performed to ensure the application of food and feed law, animal health and animal welfare rules, plant health and plant protection products. Available online: https://eur-lex.europa.eu/legal-content/BG/TXT/?uri=celex%3A32017R0625 (accessed on 17 December 2024).
69. Regulation (EC) 2073/2005 of 15 November 2005 on microbiological criteria for foodstuffs (Text with EEA relevance). Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32005R2073 (accessed on 9 December 2024).
70. Zhechev, V. A dive into the marketing trends of 2024: insights to unlocking potential. *Business & Management Compass* ***2024***, *68(1)*, pp. 54–65. doi:10.56065/p9rsad98.

 doi:10.20944/preprints202503.0863.v1

71. Regulation (EC) No 1441/2007 of 5 December 2007 amending Regulation (EC) No 2073/2005 on microbiological criteria for foodstuffs (Text with EEA relevance). Available online: https://eur-lex.europa.eu/eli/reg/2007/1441/oj/eng (accessed on 09 December 2024).
72. Regulation (EC) No 333/2007 of 28 March 2007 laying down the methods of sampling and analysis for the official control of the levels of lead, cadmium, mercury, inorganic tin, 3-MCPD and benzo(a)pyrene in foodstuffs. Available online: https://eur-lex.europa.eu/eli/reg/2007/333/oj/eng (accessed on 05 September 2024).
73. Regulation (EU) 915/2023 on maximum levels for certain contaminants in food. Available online: https://eur-lex.europa.eu/BG/legal-content/summary/maximum-levels-for-certain-contaminants-in-food.html (accessed on 07 December 2024).
74. Regulation (EC) No 396/2005 of the European Parliament and of the Council of 23 February 2005 on maximum residue levels of pesticides in and on food or feed of plant or animal origin and amending Council Directive 91/414/EEC (Text with EEA relevance) (OJ L 70, 16.3.2005, p. 1). Available online: https://eur-lex.europa.eu/legal-content/BG/TXT/PDF/?uri=CELEX:02005R0396-20080410&from=LV (accessed on 05 September 2024).
75. Stoyanova, A. The Global GAP standard - a guarantee of the quality and safety of agricultural products. *Collection of reports from a scientific-practical electronic conference with international participation* ***2012***, pp. 174-184.
76. Market research Future. Global Apricot Market Overview. Available online: https://www.marketresearchfuture.com/reports/apricot-market-23066 (accessed on 30 December 2024).
77. Mawari, G.; Kumar, N.; Sarkar, S.; Daga, M.; Singh, M.; Joshi, T.; Khan, T. Heavy metal accumulation in fruits and vegetables and human health risk assessment: findings from Maharashtra India, *Environ. Health Insights*, ***2022***, *16,* Article 11786302221119151, 10.1177/11786302221119151
78. Ambi, A.; Fibi, M.; Dahiru, D.; Mahdi, Z.; Kobbe, A.; Dabo, A.; Oladimeji, R.; Abubakar, H.; Musa, N.; Zaranda, S.; Abubakara, N. Determination of some heavy metals' concentration in selected fruits and vegetables. *International Journal of Bioscience and Agrological Research*, ***2024***, *5(1),* pp. 113-124. https://harvardpublications.com/hijbar/article/view/152
79. Kalyabina, V.; Esimbekova, E.; Kopylova, K.; Kratasyuk, V. Pesticides: formulants, distribution pathways and effects on human health – a review, *Toxicology Reports*, ***2021***, *8,* pp. 1179-1192, https://doi.org/10.1016/j.toxrep.2021.06.004.
80. Balkrishna, A.; Kumari, A. Kumar, A.; Arya, V.; Chauhan, A.; Upadhyay, N.; Guleria, I.; Amarowicz, R.; Kumar, D.; Kuca, K. Biosensors for detection of pesticide residue, mycotoxins and heavy metals in fruits and vegetables: A concise review, *Microchemical Journal*, ***2024***, *205*, https://doi.org/10.1016/j.microc.2024.111292.
81. Carvalho, F. Pesticides, environment, and food safety. *Food and energy security* ***2017***, *6, 2,* pp. 48-60.
82. Vachkova-Petrova, R. *Health risk assessment of pesticide residues in food. 2010*, pp. 49, Available online: https://focalpointbg.com/images/stories/ocenka-risk-pesticidi.pdf (accessed on 30 December 2024).
83. Reeves, W.; McGuire, M.; Stokes, M.; Vicini, J. Assessing the Safety of Pesticides in Food: How Current Regulations Protect Human Health. *Advances in Nutrition* ***2019***, *10, 1,* pp. 80–88.
84. Shtereva, D. Pesticide residues in plant products – assessment of consumer exposure. *Scientific papers of the University of Ruse* ***2010***, *49, series 1.1.,* pp. 50-54, https://conf.uni-ruse.bg/bg/docs/cp10/1.1/1.1-10.pdf
85. Bogoeva, I. Pesticides in food – toxicity and health risks. Pesticide regulation. MAF, Center for Food Chain Risk Assessment. 2023 pp. 19, Available online: https://corhv.government.bg/files/%D0%9D%D0%B0%D1%83%D1%87%D0%BD%D0%B8%20%D0%B8%D0%BD%D1%84%D0%BE%D1%80%D0%BC%D0%B0%D1%86%D0%B8%D0%B8%20%D0%B8%20%D0%B0%D0%BD%D0%B0%D0%BB%D0%B8%D0%B7%D0%B8/04_%D0%9F%D1%80%D0%BE%D0%B4%D1%83%D0%BA%D1%82%D0%B8%20%D0%B7%D0%B0%20%D1%80%D0%B0%D1%81%D1%82%D0%B8%D1%82%D0%B5%D0%BB%D0%BD%D0%B0%20%D0%B7%D0%B0%D1%89%D0%B8%D1%82%D0%B0/2023/PESTICIDES_IN_FOOD_HEALTH_RISK_Bogoeva_2023.pdf (accessed on 30 December 2024).

 doi:10.20944/preprints202503.0863.v1

86. Maximum residue levels of pesticides. European Commission. Available online: https://food.ec.europa.eu/plants/pesticides/eu-pesticides-database_en; apricots - https://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/start/screen/products/details/30 (accessed on 07 January 2025).
87. Tabanova, M.; Stratev, D.; Pashov, T. *Food Safety*. Publisher: Ministry of education and science, Bulgaria, 2021, pp. 258.
88. Enikova, R. *Methodological guidance for national microbiological criteria for food products not subject to EU Regulation 2073/2005 and EU Regulation 1441/2007*, Publisher: National Center for Public Health, Bulgaria, 2011; pp. 68.
89. Avila-Novoa, M.; Solis-Velazquez, O.; Guerrero-Medina, P.; Martínez-Chávez, L.; Martínez-Gonzáles, N.; Gutiérrez-Lomelí, M. *Listeria monocytogenes* in Fruits and Vegetables: Antimicrobial Resistance, Biofilm, and Genomic Insights. *Antibiotics* ***2024***. *13(11):1039*. Available online: https://doi.org/10.3390/antibiotics13111039 (accessed on 07 January 2025).