

Derleme Makalesi - Review Article

## Aflatoxin Problem in International Trade of Pistachios and Solution Suggestions

### Antep Fıstığının Uluslararası Ticaretinde Aflatoksin Sorunu ve Çözüm Önerileri

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#### ABSTRACT

Consumption of hard-shelled fruits is increasing because of containing high amounts of mineral substances, vitamins, antioxidants, and polyphenols. Aflatoxins are toxic substances usually produced by fungi called *Aspergillus flavus* or *Aspergillus parasiticus* and have carcinogenic effect. Aflatoxin contamination in hard-shelled fruits, which have an important place in the domestic and foreign markets, is one of the leading negative situations that threaten human health and cause serious economic losses to producers in international markets. For this reason, aflatoxin contamination limit has been set for each hard-shelled fruit traded by food organizations. Fresh fruits, vegetables, and hard-shelled fruits have a substantial share in our country's agricultural exports. Among the hard-shelled fruits, pistachio is a product with high economic value and highly demanded both at national and international. Producer companies are worried about some obstacles and economic losses in the international trade of pistachios. In this study, the factors that cause aflatoxin in pistachios and solutions are discussed. In addition, it is the basis of the study to control possible food safety hazards that are harmful to human health and to contribute to the prevention of economic losses experienced by producers in national or international trade.

**Keywords-** *Pistachio, Aflatoxin, Food Safety, Quality, International Trade*

#### ÖZ

Sert kabuklu meyvelerin tüketimi, yüksek miktarda mineral madde, vitamin, antioksidan ve polifenollerini içermesinden dolayı artmaktadır. Aflatoksinler, genellikle *Aspergillus flavus* veya *Aspergillus parasiticus* türü küfler tarafından üretilen toksik maddeler olup insanlarda kansorejen etki gösterebilirler. İç ve dış pazar da önemli bir yere sahip olan sert kabuklu meyvelerde aflatoksin kontaminasyonu, insan sağlığını tehdit eden ve üreticileri uluslararası pazarlarda ciddi ekonomik kayıplara uğratan olumsuz durumların başında yer almaktadır. Bu sebepten, gıda örgütleri tarafından ticareti yapılan her sert kabuklu meyve için aflatoksin bulaşma sınırı konulmuştur. Ülkemiz tarım ihracatında taze meyve sebze ile sert kabuklu meyveler azımsanmayacak bir paya sahiptir. Sert kabuklu meyveler arasında Antep fıstığı, ekonomik değeri yüksek, gerek yurt içi gerekse yurt dışında oldukça talep gören bir üründür. Antep fıstığının uluslararası ticaretinde bazı engeller ve uğrayabilecekleri olası ekonomik zararlar üretici firmaları tedirgin etmektedir. Bu çalışmada, Antep fıstığında aflatoksinine sebep olan faktörler ve çözüm önerileri ele alınmıştır. Ayrıca, insan sağlığına zararlı olası gıda güvenliği tehlikelerini kontrol altına almak ve üreticilerin ulusal veya uluslararası ticarete yaşadığı ekonomik kayıpların engellenmesine katkıda bulunmak çalışmanın temelini oluşturmaktadır.

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## I. INTRODUCTION

Although the trade volume is similar to the economic situation of the countries, the trade of agricultural products is different from the general trade. Agricultural trade is affected by many factors such as agricultural policies, exchange rate, population growth, especially the amount of production. Agricultural foreign trade, which is an important pillar of the economy in most countries, also provides motivation for more production and creates employment [1]. Agriculture is a strategic sector for our country, as it is for all countries, due to its increasing food demands, its contribution to national income and employment through agriculture-based industries, its effects on demographic and socio-cultural structure, biological diversity and environment. Since the raw material of the food industry is obtained through agricultural production, the food and agriculture sectors are directly related to each other [2]. Many studies have been conducted on the production steps, import and export potential, economic value, and health effects of pistachios. In this study, the precautions to be taken from the soil to the end consumer in order to prevent the aflatoxin problem, which is one of the factors that cause the most economic loss in Pistachio, which is an important export product for our country, unlike other studies, are mentioned.

## II. PRODUCTION, TRADE AND USAGE AREAS OF PISTACHIO

Pistachio (*Pistacia vera* L.) is an edible shell fruit from the gum tree family (Anacardiaceae). This fruit, which has been mentioned for centuries, is known as the "King of Fruits". It can be said that pistachio basically has two gene centers. These are the Central Asian gene center (North of India, Afghanistan, and Tajikistan) and the Near East Gene Center (Anatolia, Caucasus, Iran and Turkmenistan) [3, 4]. One of the gene centers of pistachio is Turkey [5]. Geographical indication application was made for pistachio on 18.09.1997 by our country, and pistachio was entitled to be a geographical indication (GI) product as of 22.04.2000 [6]. According to FAO data, Iran is the largest pistachio producer in the world, followed by the USA. Turkey is the 3rd biggest producer [6]. Pistachio production area in our country has increased from 2.2 million decares to 3.7 million decares in the last ten years. In addition, apart from the genetic characteristics of pistachio varieties, the amount of production fluctuates with the precipitation of the region [7-9]. While there was a serious decrease in the amount of production in the year following the severe drought, it was determined that a high amount of product could be obtained in the year after the year with good precipitation. Pistachio cultivation in our country is widely carried out in Gaziantep, Şanlıurfa, Siirt, Adıyaman and Kahramanmaraş [10]. On the basis of cities, the cities with the highest increase in pistachio production percentage in the last four years are Batman (203%), Mardin (117%) and Mersin (107%), respectively. [8]. The export of this product, which is in demand both at national and international, was 2,600 tons in Turkey in the 2019-2020 market period, according to TUIK data. Italy ranks first in exports with a rate of 36% and 935 tons. Italy is followed by Germany with 396 tons (15%), Israel with 232 tons (9%) and Syria (4%) with 103 tons. In the same market period, Turkey's pistachio export value reached 50.5 million dollars, and 95% of this value was obtained from unshelled pistachios [11]. However, despite the increase in cultivation areas in our country in recent years, it is seen that the expected increase in the amount of pistachio has not occurred. It can be said that the reason for the lack of increase is the inadequacy of gardening, processing techniques (such as irrigation, fertilization, pruning and soil cultivation), cultivation technique, pollination and fertilization biology and farmer education [3]. According to a study, it was determined that pistachio prices followed an increasing trend every year in the 2008-2018 period. In addition, compared to the price in 2008, pistachio prices in 2018 increased 4.35 times. Competitiveness of Turkey's Pistachio foreign trade was followed in the period of 2012-2017. During this period, Comparative Advantage Coefficient was 9.40 in 2012, it increased to 19.05 in 2016. If the mentioned index value is greater than 1, it is said that that country has competitive power in the relevant sector. However, it may be possible to increase production, competence and competitiveness in exports with the measures that our country will take in pistachio production [12].

Pistachios are mostly consumed in the form of snacks, as well as being preferred to increase nutrient, color and flavor in the production of foods such as chocolate, baklava, cake, ice cream, salami, sausage and sausage. Siirt and Ohadi varieties are mostly consumed as snacks due to their round shape and high cracking rate, while Red, Halabi and Uzun varieties are preferred as raw materials in the confectionery and bakery products industries due to their high aroma properties, taste and dark green color [4,13,14]. While pistachio fruit has higher protein, carbohydrate and caloric value than oily fruits such as hazelnut, almond and peanut in terms of nutritional content, it ranks second after hazelnut in terms of fat content. Pistachios have a low saturated fat content and are a good source of monounsaturated fatty acids. Most of the pistachios produced in our country (60-70%) are consumed as salted-roasted and 30-40% are consumed in the dessert and pastry (ice cream and baklava) industries, while in the USA and Europe 90% is consumed as snacks [10].

### III. MYCOTOXINS AND AFLATOXIN

Mycotoxins, which are a threat to human health due to incorrect harvesting and processing techniques for this export product with high economic value, are faced with the problem of aflatoxin, especially. Mycotoxins are generally defined as toxic metabolites produced by some species of molds of the genus *Aspergillus*, *Penicillium*, and *Fusarium* [15, 16]. Today, more than 400 known toxins such as aflatoxins, fumonisins, ochratoxins, zearalenones and trichothecenes have been identified under the title of mycotoxins [17-20]. Mold spores of fungi that produce mycotoxins can be carried everywhere by wind and air currents. With this transport process, mold spores begin to synthesize mycotoxins by reproducing and developing when suitable conditions occur [21]. It can be said that approximately 25% of the agricultural products produced in the world and feeds are contaminated with mycotoxins at a higher rate [22,23]. They are transmitted to human either by animal products contaminated with mycotoxins, or by direct consumption of plants with mycotoxins[24,25].

Probably the most known and researched toxic mycotoxins worldwide are aflatoxins [26]. Among the most common aflatoxins (B1, B2, G1 and G2), the most dangerous is the B1 group [27].

In recent years, the attention given to the health risks associated with the consumption of aflatoxins in food and feed products has increased significantly. As a result, there have been many studies showing adverse health effects in humans and animals exposed to aflatoxin contamination [28,23]. The total amount of aflatoxins that can be found in pistachios sold in the USA is expected to be less than 20 ppb [31,32]. According to RASFF (Rapid Alert System for Food and Feed) data, 89% of 5045 mycotoxin notifications in foods between 2010 and 2019 were aflatoxin-based. It was also stated that pistachio had the highest share (42%) among aflatoxin notifications. Pistachio was followed by peanuts (34%) and almonds (22%), respectively [33]. Studies have also shown that relative humidity and temperature are two important parameters in the development of aflatoxins [34, 35]. Aflatoxins produced by *Aspergillus flavus* and *Aspergillus parasiticus* occur at 25-35°C, pH range of 3.5-8.0 and water activity varying between 0.95-0.99 [17, 25, 36-38]. In many countries, the amount of mycotoxins in foods and feeds is monitored by mycotoxin contamination analysis programs. The Codex Committee on Contaminants in Foodstuffs (CCCF), which continues its activities under the Codex Alimentarius Commission (CAC), which was established in 1963 within the body of the World Health Organization (WHO) and the Food and Agriculture Organization (FAO), has an important place in terms of production and export in our country, continues to work on pistachio, hazelnuts and dried figs. At the beginning of the problems in the export of these products to the EU is the low aflatoxin limits demanded by the EU [39-42].

### IV. METHODS FOR REDUCING AFLATOXIN AMOUNT IN PISTACHIOS

Many techniques are applied to break down mycotoxins, prevent their formation or eliminate the toxic effects of mycotoxins. These techniques can be listed as removing contaminated foodstuffs, thermal treatments, precipitation process, ozone application, use of additives and biological applications. In addition, it can be said that the amount of aflatoxin can be significantly reduced in fresh pistachios using modified atmosphere packaging (N<sub>2</sub>) and spraying with antimicrobial agents (ZnO) [43]. However, although these researched techniques are effective to a certain extent; it has several important disadvantages such as not providing sufficient decontamination level, causing loss of nutritional value of the applied foods, leaving residues in the food, requiring high cost and causing the formation of toxic metabolites. In addition, these techniques are mostly laboratory-level small systems consisting of equipment that is economically limited in industry and requires high costs. For these reasons, it is concluded that it is necessary to develop new methods by improving the properties such as process efficiency, processing time, and reduction of toxic effects [44,45]. There are different approaches to reduce the amount of aflatoxin in hard-shelled fruits such as pistachios with natural or most natural methods that will not cause toxic effects. One of these methods, which does not leave toxic residues, is the use of binding agents (such as silicates, complex carbohydrate polymers, activated carbon, lemon juice, citric acid) to reduce the amount of aflatoxin [46, 47]. In addition, in a study on mice, it was determined that the yeast *Saccharomyces cerevisiae* with the GRAS (considered safe) structure provided a significant decrease in the amount of aflatoxin given to the mice with the diet [48, 49]. In a different study, it was revealed that the amount of aflatoxin present in pistachio was reduced by using atoxygenic isolates of *A. flavus* [31]. In recent years, there have been many studies showing that isolates and proteins of biologically various microorganisms reduce the amount of aflatoxin, as well as examining the effects of gamma radiation on aflatoxins is a relatively new research area. It has been determined that the amount of aflatoxin in pistachio can be reduced by 97% with gamma radiation [50]. Aflatoxins can reproduce during harvesting, drying, storage and processing of the product, or they can develop while the product is in the

field or in the garden [51]. In the following titles, critical points related to the prevention of aflatoxin growth in pistachios from pre-harvest to the final consumer are mentioned.

Pistachios are susceptible to insect infestation in May and June, when the skins of the fruits are still soft, and therefore farmers apply plant protection products against pests. Excessive irrigation of fruits while the tree is still is one of the factors that increase the risk of aflatoxin. For this, the farmer should be trained on these issues. Ripening begins in July and ends in the last days of August, when the harvest begins. If insect infestations are not above the threshold values, crop protection products are generally not preferred at this stage [52]. Aflatoxin risk increases in pistachios that are not harvested on time [53]. For this reason, the right harvest time is an important step in preventing the risk of aflatoxin. Delayed harvest not only increases the level of aflatoxin in the product, but also increases the amount present in contaminated products to high levels. A study conducted in the USA showed that a 12-day delay in pistachio harvest increased aflatoxin contamination approximately 3-fold [54]. The cracked areas in pistachios are quite open to insect attacks. Another important issue to be considered while harvesting pistachios is that the fruit does not come into direct contact with the soil. A flat oxinogenicity was recorded as 47% in fruits that fell to the ground near harvest. For this reason, it is recommended to separate the pistachios that have come into contact with the ground from the ones that have not, and to select them and to pack the fruits separately. It has been observed that aflatoxin growth is completely in the orchard in pistachios processed in the USA and it has been stated that it does not increase during processing [38]. Harvest is the most important part in the formation of aflatoxin. If aflatoxin has formed in the pistachios during the harvest period, it will be a critical control point to work on not increasing the amount of aflatoxin in the next stages, to control the risk, and to prevent the infected pistachios from contaminating the uninfected product.

Drying process in pistachios is a critical quality control step in preventing the risk of aflatoxin. Drying process is done in shell or shell form after harvest. The risk of aflatoxin in pistachios whose soft shell is roasted and dried after harvest is less than pistachios that are dried in shell and then processed. This is due to the fact that the shelled dried pistachios are uncontrollably roasted with high amounts of water and not adequately dried. For this, the risk factor is minimized by drying the dry outer shell products quickly with suitable mechanical dryers immediately after roasting in the pistachio processing plants. Spawning with steam is more controlled than spalling with direct water. If slaking is done with water, which is the classical method, the water used in the slaking phase should be of potable quality and water analyzes should be done regularly. Apart from this, the competence and training of the personnel performing the roasting process in the production facility, their monitoring by competent personnel when the mechanical drying system is active, the recording of the results by regularly measuring the temperature and humidity of the roasted and drying product will provide positive contributions in preventing the risk.

There is a risk of aflatoxin contamination of pistachios during storage [49,51]. Correct preservation methods gain importance in preventing quality losses in foods. Water activity, relative humidity, amount of water, moisture balance, dry matter ratio and osmotic pressure are important parameters in the preservation of the quality of the products [38]. Since there is no licensed warehousing in pistachios, the products are stored in unused parts of houses and workplaces or in rental shops and hangars under adverse conditions before arriving at pistachio processing facilities. In addition, stocking culture is common among traders, and product storage in modern warehouses is seen as an additional burden for brokers. It is important to make laws that have sanction in this regard, to tighten the control, and to train the farmer and the broker in this regard in order to obtain healthier pistachios. In general, following some critical rules while storing Pistachio in production facilities prevent the formation of aflatoxin in the product. During storage, keeping the product in the right packaging prevents the formation of aflatoxin. Preserving the pistachios in jute bags, if the pistachios are stored, keeping the product in vacuum packaging reduces the risk of aflatoxin contamination. In order to avoid economic losses, the warehouses where the pistachios are stored must have some qualifications. First of all, the warehouses should be of a cool and dry nature. Since aflatoxin development is observed in areas where large quantities of products are stored, if the environment is not adequately ventilated, storage areas should be ventilated naturally or mechanically, and appropriate ventilation systems should be installed in the warehouse. Wooden pallets should not be used in the storage area; plastic pallets should be preferred instead. Products that are microbiologically spoiled, past the recommended expiry date, unpackaged or open, and without label information should not be stored. The products entering the warehouse should be labeled and tracked with the lot number. In accordance with the first-in, first-out principle, products should be placed in a first-come-first-out manner. The temperature of the warehouses should be observed in the morning and evening and their verification should be done at certain times. The control results should be recorded in the temperature control chart. It is important that the optimum temperature remains

constant throughout storage. In addition, it will be healthier to store fruits with different storage temperatures separately. While pistachios generally have 65-70% relative humidity, 0-7.2°C temperature and 4-6% moisture content in shell, 1 year; if it is unshelled at 0°C, it can be stored for up to 1 year without losing its quality. In addition, it can be stored for up to 3 years at 65-70% relative humidity and -18°C as shelled and unshelled [13].

“Good Agricultural Applications” should be adopted before and during the harvest period for pistachios. It is the most important part of the measures taken at the point of preventing the risk of aflatoxin in the process that starts in the soil, before the harvest and during the harvest period. Separating the pistachios that have come into contact with the soil during the harvest period is one of the first steps to take the risk under control. It is important that the intermediary companies preserve the fruits in suitable conditions. In this regard, government incentives should be increased for the construction of modern warehouses. Industrialists need to adopt some hygiene and quality policies in their facilities in order not to deteriorate the quality of the pistachios that come to the production facilities for processing and to deliver them to the end consumer as a healthy product. During the production phase, cleaning of machinery, tools and equipment should be done in detail and regularly. The industrialist should take the necessary responsibility for the adoption of quality standards in the process from raw material acceptance to the final product, controlling and monitoring every stage of production in detail, and an accurate storage method and subsequent transportation.

## V. CONCLUSION

Contamination of aflatoxins with food is a serious health problem. The starting point of aflatoxin formation in pistachios is pistachio orchards. While the fruits are on the tree, the wrong operations applied during and after the harvest increase the risk factor. Pistachio harvest should be done on time. Pistachio trees should not be over-irrigated. Correct and effective spraying should be done while the fruits are on the branch, and pests should be combated. Delayed harvest and over-ripening of the fruit allow the development of aflatoxin. Pistachio traders must store pistachios from the farmer with the right techniques. The trader should distinguish between healthy and problematic products without showing economic concern and should not confuse them. Pistachio processing facilities should adopt food safety quality standards, facilities should comply with regulations and be hygienic. The facilities should be cleaned periodically and the cleaning should be done effectively. Aflatoxin measurements should be made at raw material acceptance and should be a critical control point in the company's HACCP system. Moisture measurements should be made regularly during product processing and should not exceed the critical value. It should be known that it is the basic duty of the farmers, traders and industrialists to take steps by considering human health in the process of this product, which is in great demand in the international market, from the garden to the end consumer. Pistachio, which is stated to be an important geographically indicated product by many researchers, should not be ignored, and its serious impact on employment, growth and development, and international trade on the macro economy. In addition, it is thought that it would be beneficial to increase government incentives in order to increase competitiveness in the international market.

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