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Aflatoxin Contamination of Pistachio and Aflatoxicose: Knowledge, Attitude, and Practices of People in Damghan City, Iran

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A R T I C L E I N F O

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A B S T R A C T

Aflatoxins are secondary metabolites that produced mainly by *Aspergillus* species in pistachio nuts or other food products. They are toxic carcinogens and mutagens that cause a variety of adverse effects such as acute and chronic poisoning, inducing cancer initiation and congenital malformation in humans and animals. This study aimed to determine level of knowledge, attitude, and practices concerning aflatoxin contamination in pistachio and its pathogenicity among members of the general public in Damghan city, Iran. This descriptive cross sectional study enrolled 297 people from the population of Damghan city in Iran in 2019 through multistage cluster sampling. Data analysis was performed by SPSS version 16. In this study, 57% (n=162) of the participants were male and the mean age was 41.81±12.1 year. Majority (40.7%) of study subjects had very poor level of knowledge, but a positive attitude (68.7%) about the aflatoxin toxicity. Also, more than 85% of study participants sometimes or always had a good practice regarding prevention of aflatoxin contamination. A significant positive correlation was found between the level of education and the knowledge and attitude scores of the participants ($p < 0.001$). Age and practice of subjects had a significant correlation ($r = 0.149$, $p = 0.021$). The findings of this study indicate a poor knowledge level of people in Damghan city. Therefore, strategies such as providing necessary training program in order to improve the level of knowledge, attitude and practices of individuals about aflatoxin should be considered.

Introduction

Pistachio (*Pistacia vera* L.) is one of the most important crops that is widely grown in Iran (Norozi *et al*., 2019; Sharifkhah et al., 2019). Aflatoxins (AF_s) are potent toxic compound bearing various effects like estrogenic, mutagenic, carcinogenic, teratogenic or acute and chronic toxicity that are associated with the development of liver cancers in humans (Pohland, Thorpe *et al*. 1990, Schatzmayr and Streit 2013). Aflatoxins are secondary metabolites produced by *Aspergillus* fungi that are able to contaminate agricultural products at both pre and post harvesting stages (Fani, Moradi *et al.*, 2014, Moradi, Fani *et al.*, 2014, Mahbobinejhad *et al.*, 2019). The crops prone to aflatoxin contamination are including peanuts, corn,

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pistachios, cotton seed, varieties of nuts, spices, figs, almonds and raisins. Some commodities such as barley, wheat, rice, sorghum, millet, soybeans and cassava are at lower risk of contamination (Tola and Kebede, 2016). Also the existence of insects and infestations make changes in humidity and ambient air temperature of surrounding crops can facilitate the growth of fungi in stored crops (Fani, Javanshah *et al*., 2014, Moradi, Hokabadi *et al*., 2015).

Pistachio nut is among foods that are invaded by aflatoxin-producing *Aspergillus* (Fani, Moradi *et al*., 2014, Abdolshahi, Marvdashti *et al*., 2019). Many factors affect the prevalence of aflatoxin in pre-harvest, harvest and post-harvest of pistachio. In pre harvest stag the control of climatic condition and soil factors, avoiding insect, and bird's infestation, avoiding drought stress, controlling of plant pathogens, water activity and maturity of pistachios (Moradi, Ershad *et al*., 2004, Taheri, Abdoshahi *et al*., 2011, Abdolshahi *et al.*, 2016). The optimum harvest time, transportation conditions, mechanical damage to kernels and timely drying of pistachios are the main factors during harvesting (Afshari and Hokmabadi, 2011). Also the storage conditions, kernel moisture contents, duration of drying, before-storage segregating to remove contaminated pistachios and hygienic conditions are the main factors influencing aflatoxin contamination after harvesting stage (Magan and Aldred, 2007, Shakerardekani, Karim *et al*., 2012, Moradi, Hokabadi *et al*., 2015, Abdolshahi, Shabani *et al*. 2018). Therefore, the control and elimination of aflatoxigenic fungi can be associated with the minimizing the risk of aflatoxin contamination in pistachio (Shakerardekani, Karim *et al*., 2012, Aldars-García, Ramos *et al*., 2015). Hence, the awareness of farmers/consumers about aflatoxin-producing fungi and also incidence of aflatoxin contamination in pistachio seems to be effectual on general public health especially in pistachio producing areas (Cheraghali, Yazdanpanah *et al*., 2007; Goldblatt, 2012). However, the accretion of people and their attitudes towards the aflatoxin contamination and also practices to adequately control exposure to this hazard play an important role in maintaining the safety of pistachio.

This study aimed to determine the level of knowledge, attitude and also practices concerning aflatoxin contamination of pistachio and its pathogenicity among members of the general public in Damghan city one of the main pistachio producing zone in Iran. The information obtained by this study will provide guidance for implementing the preventive strategies required for mitigating the risk of aflatoxin exposure and also its subsequent devastating effects on the economic, social and cultural of the studied area.

Materials and Methods

This descriptive cross-sectional study was performed on 300 member of population of Damghan city in 2019. Sample size was calculated according to the formula: n= $(\frac{zs}{d})2$. Multistage cluster sampling was performed stratified by geographical areas of Damghan city.

Data collecting was performed through a researcher-made questionnaire. The questionnaire consisted of four parts. The first part was devoted to demographic data (6 questions) including age, sex, occupation, level of education and marital status. Part II was related to the level of knowledge (10 questions), including the awareness of participants about the nature of aflatoxin, way of producing aflatoxins, transformation of aflatoxin into human body, adverse effect of aflatoxins in humans, pathogenicity of aflatoxin, the role of individual health in preventing the spread of aflatoxin, role of agricultural and horticultural methods in preventing the incidence of aflatoxin and the potential impacts of aflatoxins contamination of pistachio on the economy of Iran country. In part III, the attitude (7 questions) of individuals about the aflatoxin control and prevention strategies, human factors influencing

aflatoxin production, role of farmers in prevention of aflatoxin contamination, and the practices of participants about the harvesting, timely drying, and storing pistachio were investigated. The score in knowledge part was calculated as the number of correct responses to the questions. The attitude and practice scores computed based on the points Likert scale. It ranged between 0 and 5 for attitude part and 0 and 4 for practice part. The content validity ratio (CVR) and the content validity index (CVI) were determined by a group of experts (10 people). All questions had a CVR above 0.79. Also, all questions had a CVI above 0.79. The internal consistency was determined by Cronbach's alpha, and it obtained 0.70. Data analysis was done by SPPS version 16and using kolmogorov-smirnov, Chi square, U Mann whitney, KruskallWallis, and Pearson and Spearman correlation coefficients The level of confidence required for significance was set at $p \leq 0.05$.

Results

In this study, 297 persons were recruited; 57% (n=162) were male and the rest were female (n=122). The mean age was 41.81±12.1 years. Table 1 shows demographic characteristics of individuals participating in the study.

Table 1. Demographic characteristics of study participants

Variables		Frequency Number (%)
Gender	Male	162 (57)
	Female	122 (43)
Age (year)	< 30	38 (14.7)
	30 – 39	93 (35.9)
	40 – 49	60 (23.2)
	50 - 59	42 (16.2)
	≥60	26 (10)
Marital status	Married	235 (83.9)
	Single	45 (16.1)
Occupation	Household	31 (11)
	Employee	158 (56.2)
	Other	92 (32.7)
Level of Education	Elementary	23 (8.3)
	High school	62 (22.5)
	Bachelor	136 (49.3)
	Master and PhD	55 (19.9)
Level of income	Low	38 (27)
	Moderate	88 (62.4)
	High	15 (10.6)
Having pistachio garden	yes	69 (24.6)
	no	211 (75.4)
Storing pistachio after harvesting	yes	10 (3.6)
	no	265 (96.4)

Data analysis showed that in the knowledge part, the mean number of corrected answers was 3.54± 0.33. Of the participants, 40.7% (n=121) of responders answered only one question. Among the designed questions, the most correct answer was related to the questions of "If the pistachio is stored in a warm and humid environment, the fungus will grow and produce Aflatoxin."Also, the mean score of attitude of the

participants was 3.73±0.52. The subjects had the most agreement on the item of "role of individual health in preventing the spread of aflatoxin". The mean practice score of study participants was 2.98±0.45. The best practice was related to "I refuse to buy rancid and stale pistachios". Level of knowledge, attitude and practice of the study participants regarding aflatoxin poisoning are shown in Table 2.

Table 2. Level of knowledge, attitude and practice of the study participants about aflatoxin poisoning

Variables		Frequency Number (%)
Level of Knowledge	Very poor	121 (40.7)
	Poor	32 (10.8)
	Fair	67 (22.6)
	Good	52 (17.5)
	Excellent	25 (8.4)
Attitude	Strongly disagree	0 (0)
	Disagree	6 (2)
	Undecided	87 (29.3)
	Agree	187 (63)
	Strongly agree	17 (5.7)
Practice	Never	0 (0)
	Rarely	37 (12.5)
	Sometimes	214 (72.1)
	Always	46 (15.5)

The relationships and correlations between levels of knowledge, attitude and practice scores and demographic characteristics of the study subjects are presented in Table 3. In the knowledge part, a significant positive correlation was found between the level of education and the knowledge level of the participants ($r = 0.221$, $p < 0.001$). Also, there was a significant relationship between having a storage for pistachio and level of knowledge ($p = 0.033$).

The level of education was significantly related to the attitude score of the participants and those with the higher level of education had a more positive attitude toward the preventing aflatoxin contamination. Also, the occupation variable had a significant relationship with the attitude score and employees had a more positive attitude than housewives ($p = 0.015$) as well as individuals with other jobs ($p = 0.003$). Housewives and individuals with other occupations had the same attitude about aflatoxin contamination ($p = 1.00$).

There was a positive and significant correlation between age and practice of subjects ($r = 0.149$, $p = 0.021$). Also, the performance of married people was significantly better than single people ($p = 0.040$).

Also, Knowledge score was positively correlated with attitude ($r=0.82$, $p<0.001$) and practice ($r=0.79$, $p<0.001$) scores. Furthermore, a significant positive correlation was found between attitude and practice scores ($r=0.89$, $p<0.001$) (Table 4).

Table 3. The relationships between knowledge, attitude and practice scores and demographic characteristics of study subjects

Variables	p-value							
	Gender	Age	Marital status	Education	occupation	Income	Having pistachio garden	Having pistachio storage
Level of Knowledge	χ^2 = 0.12 p= 0.699	r=0.096 p= 0.124	χ^2 = 0.17 p= 0.621	r= 0.221 p<0.001	χ^2 = 0.72 p= 0.261	r= 0.054 p=0.523	χ^2 = 0.29 p= 0.434	χ^2 = 1.23 p= 0.033
Attitude	χ^2 = 0.36 p= 0.218	r=0.002 p= 0.977	χ^2 = 0.64 p= 0.057	r= 0.254 p<0.001	χ^2 = 3.37 p<0.001	r= 0.077 p=0.367	χ^2 = 0.13 p= 0.584	χ^2 = 0.41 p= 0.215
Practice	χ^2 = 0.69 p= 0.053	r=0.149 p= 0.021	χ^2 = 0.92 p= 0.040	r=- 0.016 p=0.796	χ^2 = 0.89 p=0.149	r= - 0.087 p=0.310	χ^2 = 0.36 p= 0.234	χ^2 = 0.27 p= 0.367

Table 4. Correlation between knowledge, attitude and practice scores of study subjects.

Variables	correlation coefficient (r), p-value		
	Level of Knowledge	Attitude	Practice
Level of Knowledge	-	r = 0.82 p< 0.001	r = 0.79 p< 0.001
Attitude	r = 0.82 p< 0.001	-	r=0.89 p< 0.001
Practice	r = 0.79 p< 0.001	r =0.89 p< 0.001	-

Discussion

This study conducted on 297 people of Damghan city in Iran to determine the level of knowledge, attitude and also practices concerning aflatoxin contamination of pistachio and its pathogenicity. Majority of participants had very poor level of knowledge, but a positive attitude about the aflatoxin toxicity. Also more than 85% of participants sometimes or always had a good practice for the prevention of aflatoxin contamination. Our results were consistent with Redzwan *et al*., (2012) (Redzwan, Mutalib *et al*., 2012), Matumba *et al*. (Matumba, Monjerezi *et al*., 2016) and Adebukola *et al*., (2015) (Adebukola, Opeyemi *et al*., 2015) studies, which reported a poor level of knowledge in their studies. In Toma *et al.* (2019) study, 45% survey respondents (farmers) were unaware about Aflatoxin (Toma, 2019). In Hassan *et al*., (2019) study that carried out among 1,263 respondents who consumed peanut and peanut-based products, about 73.9% of total respondents have inadequate knowledge and only 26.1% have adequate knowledge towards the risks of contaminated products (Hassan, Kamarulzaman *et al*., 2019). While in Janjani *et al*., (2018) study, participants obtained a good knowledge and performance scores (Janjani, Mehralian *et al*., 2018). Haji Mohammadi *et al*. (2015) found that 42.5% of their study subjects had good knowledge and also 59.4% and 91.7% of them had good attitude and practice, respectively (Haji, Ehrampoush *et al*., 2015). Shafieian *et al*., (2015) also showed that 77.6% of participants had a moderate attitude (Shafieian, 2015). In Azaman *et al*. (2016) study, majority of stakeholders (89.9%) had general knowledge about aflatoxins contamination and also had favorable attitude towards mitigating aflatoxins contamination. In their study, the most of participants had high practices regarding reduction of aflatoxins contamination (Azaman, Kamarulzaman *et al*. 2016).

The results of these studies were in contrast with the finding of present study. Various factors can influence the level of knowledge, attitude and performance of people toward reducing aflatoxin contamination, including hygiene and training programs, quality of assurance certification, time lag and locality attributes of conducted studies, income inequalities, government training programs, nature of the study population and the motivation of people (Redzwan, Mutalib *et al*., 2012, Ayo, Matemu *et al*., 2018, Hassan, Kamarulzaman *et al*., 2019).

In our study, significant positive correlations were found between the level of education and the knowledge and attitude scores toward the preventing aflatoxin contamination in which the individuals with the higher level of education had a more level of knowledge and positive attitude. In a study by Akhundi *et al*., conducted on farmers, the knowledge of farmers had a significant and positive correlation with their level of education (Akhondi, Pezeshkirad *et al*., 2007). In Haji Mohammadi *et al*., (2015) study, there was a significant difference between the level of education with knowledge and practice, so that women with postgraduate and higher education had the highest score of knowledge and practice regarding food poisoning compared to other groups(Haji, Ehrampoush *et al*., 2015). In Ayo *et al*., (2018), farmers with higher level of education (≥secondary education) were twice more aware on aflatoxin contamination than those with lower education (Ayo, Matemu *et al*., 2018). This result concurs our finding obtained about knowledge and attitude and inconsistent with practice of participants. Furthermore, a study by Abbot *et al*., (2009) revealed that 60% of people with a high school diploma are familiar with foodborne poisoning(Abbot, Byrd-Bredbenner *et al*., 2009). However, results of the present study were similar to the finding of Shafieian *et al*., (Shafieian, 2015), Dosman *et al*. (Dosman, Adamowicz *et al*. 2001)and Adebukola *et al*. studies (Adebukola, Opeyemi *et al*., 2015). The level of education seemed to be the major factors influencing the knowledge, attitude and practice of aflatoxin contamination. Therefore, it can be expected that by improving literacy, knowledge of individuals, especially farmers, about the preventing incidence of aflatoxin can be enhanced.

According to our finding, the occupation variable was significantly related with the attitude score and employees had a more positive attitude than housewives as well as individuals in other occupations. Guchi *et al*., (2014) revealed that farmers had a less information about aflatoxins than individuals in other occupations (Guchi, Ayalew *et al*., 2014). Also, the performance of married people was significantly better than single people ($p = 0.040$). In agreement with our results, Janjani *et al*., found that there was a significant difference between married and single individuals in term of knowledge score and married people had higher mean scores (Janjani, Mehralian *et al*., 2018).

Also, the relationship between having storage for pistachio and level of knowledge was significant. In Azman *et al*., (2016), hygiene practices were 1.43 times higher in individuals who implemented a proper storage of their products (Azaman, Kamarulzaman *et al*., 2016), which concurs our result. There was a positive and significant correlation between age and practice of subjects about aflatoxin and the associated health impacts ($r = 0.149$, $p = 0.021$). While, Lee *et al*., (2017) concluded that young farmers (at age of 21–29) had more awareness about aflatoxins in crops than the older groups(Lee, Nguyen-Viet *et al*., 2017). It is recommended more studies aimed to examine the role of socioeconomic characteristics in access of knowledge, positive attitude and good practice toward aflatoxin poisoning.

The findings of the present study indicate a positive and significant correlation between knowledge, attitude and practice scores regarding aflatoxin contamination of pistachio among the people living in Damghan city.

These findings suggest that practice to control and management of aflatoxin pathogenicity will be improved by increasing the knowledge and attitude of participants about the aflatoxin toxicity. Based on the results of this study, lower age, lack of a suitable storage and low education level can be associated with the negative impact on the knowledge, attitude and practice of people about aflatoxin contamination. It is recommended the authorities introduce aflatoxin poison and associated health problems in curricula for schools and health colleges to increase access of awareness to aflatoxin.

Conflict of interests

The authors declare not having any personal or financial support or involvement with organizations with financial interest in the subject matter or any actual or potential conflict of interest.

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