IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 13, Issue 4 Ser. I (April. 2019), PP 70-76
www.iosrjournals.org

Chemical and Microbial Environmental Contaminants in Fruits and Vegetables and their Effects on Health: A Mini Review

Ashraf O. Khashroom[1], Shamaail A. Saewan[2], Saher S. George[2], Hani J. Hamad[3]

[1]*Department of Plant Production and Protection, Faculty of Agriculture, Jerash University, Jordan.*
[2]*Department of Food Science, College of Agriculture, University of Basrah, Iraq.*
[3]*Department of Food Science and Nutrition, Faculty of Agriculture, Jerash University, Jordan.*
Corresponding Author: Shamaail A. Saewan

Abstract: *The fresh food products like fruits and vegetables became an important element in the consumer's daily meal in view of their high nutritional value, low caloric value, availability, and somewhat low prices. Most of the fruits and vegetables contain a high percentage of water that ranges from 78% in potatoes to 94.8% in lettuce. As well, their protein and fat contents do not exceed 3.5% and 0.5%, respectively, except some cases such as raisin and dates, whose water content is low and which can not be considered as fresh in comparison with other fruits. Demand on these products is ever growing. But, similar to other agricultural products, they are prone to pollution and/or spoilage, either naturally or by human interference. The first manifestation of spoilage starts from the soil in which the crops are planted as a result of their pollution with acidic rain water or polluted irrigation water; human and animal wastes; sanitary drainage water (sewage); fertilizer and pesticide residues; oil pollution; and microbial pollution with bacteria, fungi, and parasites of their various types, as well as the residual toxins and excretions which result from them and that adversely impact the agricultural products, and, in consequence, consumer's health. Use of organic fertilizers is regarded as safer than use of chemical fertilizers. If the latter are used rationally and at concentration that does not exceed 300 kg/ha, then this will not lead to accumulation of the toxic chemical elements in the soil (Moustafa, 2018). Hence comes the importance of finding the suitable ways and solutions for reducing extent of hazard of these pollutants through which (the solutions) the consumer guarantees her/his safety and non-exposure to diseases, as well as reducing the treatment costs resulting from effects of pollution of its different kinds.*

Keywords*: Environmental Pollution, Fruit Pollution, Vegetable Spoilage, Heavy Metals, Polycyclic Aromatic Hydrocarbons (PAHs), Fertilizers, Agricultural Pesticides, Polluting Bacteria, Fungi.*

Date of Submission: 12-04-2019 Date of acceptance: 27-04-2019

I. Introduction

The fresh food products like fruits and vegetables have become to greatly influence human food in view of their nutritional value and health benefits. Daily consumption of 400 g of fruits and vegetables noticeably prevents incidence of some chronic diseases such as heart diseases, hypertension, cancer, diabetes, and obesity. Demand for these fresh products continues to increase yearly with increase in consumer's awareness of their health benefits. In addition, the shift in the human lifestyle led to an increase on the demand for fruits and vegetables because the consumers look for the more healthy option. Here, the fruits and vegetables are considered as important in the food meal, e.g., their use in preparation of ready-to-eat salad and other things. It is anticipated that consumption of fresh fruits and vegetables will increase by 24-27% and 19-24%, respectively, by 2020 (Hassan and Purwani, 2016).

Human's interest and care to consume clean and healthy food that is free of pathogens became one of the important matters in his life that we find him always seeking to work by. Technology and modern life became sources consequent to which a growth in the proportions of pollutants of their different forms took place. Perhaps the fresh agricultural products, including the fruits and vegetables, are among the foods most exposed to the different types of pollutants. Working on providing fresh food that is free of pollutant traces/residues grew an intractable matter that needs continuous follow up, large efforts, and expenditure of more money (Assayyed Yousof, 2015).

Pollution of the fresh products during the circulation process is counted as a popular problem which is usually overlooked by using the appropriate technology to remove the pollution as consumption of polluted fruits and vegetables can lead to incidence of food poisoning due to presence of wastes and microbes on the outer surfaces of these products. Additionally, the surrounding environment changes continuously with presence

of drug-resistant microbes in the air, soil, and water. These changes can directly influence the patterns of the food poisoning incidences and the numbers of affected persons and deaths (Mathur *et al*., 2014).

Chemical Content and the Nutritional Value of Fruits and Vegetables

Rather et al (2017) reported in their article "The phrase chemical contamination is a clear indication of the presence of chemicals where they should not be or are present in an amount that is in a higher concentration than the amount that is attributed as safe. The chemical hazards are one of the main causes of food contamination that associated with foodborne disease outbreaks. The origins of chemical contaminants are various from the field to the plate, namely soil, environment, disinfection by-products, personal care products, air, water, and packaging material. Chemical contaminants inhibit almost all the mass-produced everyday use products such as disinfectants, plastics, detergents, deodorants, pesticides, and so on".

Most of the fruits and vegetables contain a high percentage of water that ranges from 78% in potatoes to 94% in lettuce, and their protein and fat contents do not exceed 3.5% and 0.5%, respectively, with the exception of some cases like raisin and dates whose water contents are usually low and which can not be regarded as fresh in comparison with other fruits. However, legumes like peas and beans contain high protein percentages and vegetables such as sweet corn and avocado contain a high fat percentage. It is worth mentioning that fruits and vegetables are considered as an important source of simple carbohydrates like sugar and complex carbohydrates such as starch and cellulose that are necessary in the digestion process. The chemical content of the fruits and vegetables varies, depending on variety, growth conditions, and method of cooking of the fruits that are manufactured. The fruits and vegetables are characterized by being among the important constituents of human food. They are an important source of minerals such as potassium, calcium, and iron, besides other basic nutrients. They are also rich in vitamins, especially vitamins A and C. The yellowish-orange fruits and the leafy vegetables contain vitamin A generators, which include B-carotene and carotenoids. Moreover, the citrus fruits, green leafy vegetables, and tomatoes are an excellent source of vitamin C. As well, potato is an important source of this vitamin, not for its high percentage in potatoes but for the large quantities of potatoes that are consumed worldwide (FAO, 1995).

Vegetables have a low caloric value. Every 100 g of them in general equips 10-50 caloric units. To obtain 1,000 calories, two to three kilograms of vegetables are due to be consumed. One of the most important features of vegetables is that they give the body a large quantity of nutritional substances with the least content of calories and fat. Many specialists in the field of nutrition advise reduction of the fats consumed and replacing them with large quantities of vegetables (Lintas, 1992). In this respect, Table 1 shows the chemical content of some fruits and vegetables.

Table 1: Chemical Content of some Fruits and Vegetables*

Substance		Carbohydrate	Protein	Fat	Ash	Water
Ground Plants	White Potatoes	18.9	2.0	0.1	1.0	78
	Sweet Potatoes	27.3	1.3	0.4	1.0	88.6
Vegetables	Carrot	9.1	1.1	0.2	1.0	88.6
	Radish	4.2	1.1	0.1	0.9	93.7
	Lemon	4.1	2.1	0.2	0.7	9.92
	Green Beans	7.6	2.4	0.2	0.7	89.1
	Fresh Peas	17.0	6.7	0.4	0.9	75.0
	Lettuce	2.8	1.3	0.2	0.9	94.8
Fruits	Banana	24.0	1.3	0.4	0.8	73.5
	Orange	11.3	0.9	0.2	0.5	87.1
	Apple	15.0	0.3	0.4	0.3	84.0
	Strawberry	8.3	0.8	0.5	0.5	89.9

* Source: Shewfelt (1990)

Manifestations of Exposure of Fruits and Vegetables to Spoilage

Bacterial Pollution

Most of the microorganisms that exist on surfaces of fruits and vegetables derive originally from the soil. They are part of a big and diverse community of microbes that are responsible all for the dynamic balance of the environment. These microbes are transported by means of soil, air, and irrigation water. Most of the bacteria and fungi which reach to the growing crops are considered as benign. They provide a natural biological barrier against infection with other microbes responsible for crop damage (Andrews and Harris, 2000). Many of the varieties of fruits and vegetables are characterized by providing ideal conditions for living of numerous microorganisms as the internal tissues of these fruits, particularly the vegetables whose pH is close to neutrality, are rich in nutrients. Tissue of fruits mainly consists of cellulose and contains starch. Microbes resort to the extracellular enzymes that destroy or degrade these polymers to liberate water and the other cell constituents so as to benefit from them as food. Fungi in particular produce a surplus of the pectin-, and hemicellulose-decomposing enzymes that are regarded as important factors for fungal spoilage (*Brath et al*., 2010).

The improper use of fruits and vegetables, especially when consuming them raw, causes big harms to the health of the consumer because of their pollution with numerous parasites. Some people resort to exposing these fruits to the sunlight as an alternative method for preserving their taste, which raises the level of presence of parasites in them and helps in their transfer to the human. Food is exposed to pollution during the processes of reaping, production, or transport. In the field, it is polluted due to use of non-thermally-modified (uncurified) manure, which increases the level of soil pollution with parasites and their eggs that are transported by means of the organic fertilizers. This, in turn, reflects on quality of the agricultural crops and raises their level of pollution with parasites and human infection with them later on. Of the other sources of plantation pollution with parasites is use of sewage for irrigation. The human being adds more than 100 different types of parasites like the round worms, cestode worms, flukes, and rudimentary worms (primates). These parasites have large detriments on the human since they affect his different tissues and organs, causing numerous health problems like diarrhea, distension, limited absorption of the nutrient substances, exhaustion, dysentery, and anemia. Some of these parasites cause asthma, arthritis, and skin ulcers (Anh, 2013).

The processes of agricultural product production, circulation, and packaging may make them susceptible to pollution with numerous food-borne pathogens. For example, some pathogenic bacteria like *Salmonella*, *Escherichia coli* (*E. coli*) O157: H7, *Campylobacter jejuni*, and *Vibrio cholerae*, may cause pollution of the fresh products through different sources such as the raw fertilizer, improper fertilizer, the animal wastes, feces, or polluted water (Gómez-Govea *et al*., 2012).

Despite that the fruits and vegetables are considered as an important part of the healthy food system for the human as a result of their richness with several nutrients, they, nevertheless, can represent a source of hazard for health. Several studies mentioned that epidemics that are transmitted through undesirable foods are tightly associated with the fresh fruits and vegetables because they can be probably polluted with a wide range of the microbial and chemical pollutants. Freshness of the fruits and vegetables and their content of nutritional components are considered as suitable factors for growth of microscopic microorganisms, whether they are causing food spoilage or food diseases. Among the pathogenic microscopic organisms that were detected in the fresh fruits and vegetables are *Enterobacter spp*., Coliforms, *Salmonella*, *Shigella*, and *Bacillus*, besides intestinal pathogens such as *Salmonella* and *E. coli*.

Fungal Pollution

Fungi play an important role in spoilage of fruits and vegetables because of their pathogenic ability to excrete poisons on crops. These fungi may produce different fungal poisons as metabolism products during different stages of pathogenesis that are poisonous to human and animal when consuming these products. Many studies, books, and references have widely dealt with the subject of fungal poisons in the agricultural crops, especially the dry products, which play an important role in international trade. During the last decades, types of fruits and vegetables have been added to the list of products that are susceptible to pollution with fungal poisons (mycotoxins) (Golan and Paster, 2008). Of the fungus types that infect the fruits and vegetables are *Alternaria*, *Pinicillium*, and *Aspergillus* that produce sorts of mycotoxins like aflatoxins, ochratoxin, and patuline (Fernández-Cruz *et al*., 2010).

Apart from what has been mentioned so far, during their production stages the dried fruits are exposed to pollution with different microscopic organisms such as fungi and bacteria, which play noticeable role in spoilage of these food products. Examples of these microscopic organisms are *Alternaria*, *Rhizopus*, *Mucor*, *Fusarium*, and *Scopulariopsis*. The species *Alternaria*, *Penicillium*, and *Aspergillus*, are considered as the species most prevalent in the dried fruits. These microbes cause big worriment as a result of their direct contribution to spread of pollution with mycotoxins and because some of them are carcinogenic. Of the most famous poisons in the dried fruits are aflatoxin, ochratoxin, citrinin cyclopiazonic acid, strigmatocystin, and patuline (Al-Haddad *et al*., 2016).

There is a degree of specificity between a particular commodity and the mould species which have overcome these barriers to produce overt spoilage. The low pH of most fruits, as low as 2·2 in the case of lemons, leads to the spoilage of this group of plant products being predominantly by fungi. Vegetables, in contrast, have pH values closer to neutrality (4·8–6·5) and, as well as fungi, bacteria play a significant role in their spoilage (Moss, 2008) . So far, little information is available about the direct chemical combat of the micotoxins in the fruits and vegetables. In this context, the chemical substances are employed to prevent and combat the toxin-producing fungi. The chemical combat mainly involves use of manufactured fungicides

Field crops can be stored in silos that meet the appropriate conditions of heat, humidity, ventilation and periodic. Some chemicals (active charcoal, bentonite, zeolite, aluminum silicate and organic acids (formic acid and acetic acid)) are also used to treat some of the fungal toxins. Chemical methods can be used to cause degradation of certain toxins such as using of ammonia and ozone. Hence, awareness campaigns should be encouraged by the Ministry of Health, civil society organizations and various media to identify the risks of fungal toxins (Saeed et al., 2016).

Pollution with Agricultural Pesticides

Pollution of fruits and vegetables with pesticides is addition, or persistence, of undesirable, harmful, strange substance that causes a change in the grade and degree of quality of these products. This, consequently, reflects on human health and exposes him to the risks of chronic toxicity and infection with serious diseases, in addition to that some organophosphorous pesticides cause incidence of neurotoxicity that ends with chronic paralysis. The chemical pesticides are counted among the most important water pollutants. This, as a result, reflects on the agricultural products. Water pollution with these pollutants takes place through washing of the pesticide residues from the cultivated lands by means of rainwater, the seasonal streams, and well water, besides sanitary drainage or discharge of wastewater of factories in the river and valley channels. It is worth pinpointing that there exist more than 500 types of insecticides in circulation in the agricultural sector (Assayyed Yousof, 2015).

Pollution due to Use of Agricultural Fertilizers

The plants are regarded as one of the important sources in the human life that satisfy some of his needs of food, drugs, and clothes. Hence, the human needs to give them their worth of the food elements necessary for their growth and for increase in productivity. These elements are represented by the agricultural fertilizers, which can be natural (i.e., organic) and industrial (that is, chemical). On the long run, excessive use of these heavy fertilizers results in their accumulation in the soil. The extent of accumulation differs according to whether the soil that is cultivated with the vegetable crops is exposed or covered. Intensive use of the heavy fertilizers in the exposed fields leads to accumulation of some heavy metals like zinc and copper at lower percentages than if the field is within a plastic house. The seed crops are characterized by their disposition to absorb and store minerals in the plant parts and seeds, which increase toxicity of the consumed seeds. Use of organic fertilizers is considered as safer than use of chemical fertilizers. If the latter are used rationally and at a concentration that does not exceed 300 kg/ha, then this will not result in accumulation of the toxic chemical elements in the soil (Moustafa, 2018).

Upon improvidence in use of these fertilizers, large part of them remains in the agricultural soil and is in excess of plant need. This, consequently, is considered as exhaustion of money in addition to its affection of environmental pollution. It was found that in the plants which contain a high percentage of the nitrate compounds in their tissues such as the legumes, carrot, celery, lettuce, and radish, part of this nitrate is converted in the body into the nitrite ion, which is affects the blood directly and prevents it from performing its main function, that is, transfer of oxygen from the lungs to all body cells. As well, some scholars think that the nitrite ion reacts with the amines present in the bodies of the living organisms, including the human being, to yield nitrosamines, which are highly toxic and whose presence in the human body represents a big hazard as it causes development of carcinogenic tumors in the liver, in particular, and in the gullet, stomach, pancreas, and lungs (Shotaywiy, 2002).

Pollution with Metal Elements

Metal pollution of the soil and plants is ascribed to the various industrial human activities, including metal smelting and painting and the rest other metal works, besides leather manufacturing and tanning, due to the gases and smoke which these activities transmit, the chemicals they leak to the water, and the solid wastes which they leave behind. The vegetables contain the toxic metal elements of both types; the essential and non-essential elements, at wide range of concentrations. The metals exist on the surfaces of the fresh vegetables and in their tissues. Heavy metals such as cadmium, copper, lead, chromium, and mercury are regarded as worrying environmental pollutants, particularly in the areas where irrigation with sewage is practiced (Thompson and Kelly, 2003; Papa *et al*., 2009).

Research results indicate that not less than 20 million hectares of the lands in north and south Africa, southern America, the Middle East, south Europe, south west of America, Mexico, and large part of middle and east Asia are irrigated with non-refined sanitary drainage water (sewage), especially the vegetables. This, in turn, reflects on pollution of the agricultural lands and accumulation of heavy metals in soil and the cultivated crops. The vegetables take the metal elements by absorbing them from the polluted soil and from deposits in the different plant parts that are exposed to air originating from polluted environments. It was reported that about half the average consumption of lead, cadmium, and mercury through food tracks back to plant origin (fruits, vegetables, and seeds). The agricultural soils polluted with metals may spread widely in the urban areas because of former industrial activity or due to use of fossil fuel in those areas (Bigdeli and Seilsepour, 2008).

It is known that pollution of food material with chemical substances and non-essential elements like the heavy metals has a series of harmful effects on the human and animal bodies; these pollutants are present everywhere and when they enter the body they cause potential hazard to it and have serious toxicity effects since they can cause faults in the cellular systems of the body through displacing the essential metals from their special locations. Deterioration of oxidation of the biological molecules is due in the first place to binding of the metals with the nucleic acid (DNA). Symptoms of metal poisoning are considered as the first indicators of incidence of pollution that help in its specification. The symptoms that arise as a result of metal poisoning include mental retardation among children, divagation among adults, disturbances of the central nervous system, kidney and liver diseases, insomnia, depression, and emotional instability. Briefly, poisoning arising from heavy metals is regarded as a big medical problem that has its negative impacts through increasing the rates of disease and death if its treatment is neglected (Jan *et al*., 2015).

Pollution with Insecticides

From time to time, the farmers spray the fruit and vegetable trees with agricultural pesticides with the goal of preserving their crops against the damage which the verminous and fungal lesions (insect and fungal pests) or rodents cause. This leads to pollution of the fruit upshots, seed crops, and vegetables with these toxic chemical compounds that enter the human body when eating the fruits and vegetables polluted with them (Assayyed Yousof, 2015) and cause carcinogenic diseases and congenital malformations, particularly since they accumulate in the human organs for long periods next to consumption of the fruits polluted with them. Some fruits and vegetables are sprayed with pesticides whose levels reach to 20 times what is recommended. Residues of these pesticides will accumulate in the fruit tissues to reach eventually to the consumer. Even if the fruits and vegetables were peeled off or if the hard shells were removed from the dregs, then this does not mean total freeness of these fruits of pesticides; tiny proportions of them might have penetrated the external fruit walls somehow (Shotaywiy, 2002).

Human exposure to the pesticides means their arrival in the human body or deposition on its surface. Their toxic effect depends on the time of exposure and the employed pesticide concentration. The human can be exposed to the pesticides in four ways: through the mouth (orally), inhalation, looking, or pesticide contact with the skin. The researchers were concerned with the problems of pesticide deposition and their adverse impacts on health and found that most of these pesticides, in specific the organochlorine pesticides, are stable against microbial disintegration, and, therefore, can accumulate in the human body rapidly and cause numerous health problems (Kumar *et al*., 2012).

Pollution with Petroleum Hydrocarbons

For the non-smokers, food polluted with petroleum hydrocarbons is the first way of pollution with poly-nuclear aromatic hydrocarbons (PAHs), which are potentially-toxic compounds that reach the human body through ingestion. Studies and research focus on presence of PAHs in fruits and vegetables. These compounds can move from the air and soil during cultivation. They may also appear before consumption during the storage, transport, or cooking processes. In the case of the PAH compounds that are classified as pollutants by the United States Environmental Protection Agency (USEPA), low quantities of PAHs are frequently detected in the fresh fruits and vegetables at concentrations ranging from 0.01 to 0.5 μg/kg on a wet-weight basis (wwb). Nonetheless, several studies indicate that concentrations of some PAHs may exceed 0.5 μg/kg wwb in the various fruits and vegetables, even reaching to 5.0 μg/kg wwb. The concentrations of these compounds may be broadly different, depending on the area surrounding the planted crops or type of the aromatic hydrocarbon, or even the produce itself. And their concentrations are usually higher in the products that grow close to the roads or in the urban areas than in the plantations that grow in rural areas. In fresh fruits and vegetables, scarce levels of some PAHs (pyrene, fluoranthene, and phenanthrene) and relatively high levels of naphthalene, acenaphthylene, and acenaphthene have been reported (Paris *et al*., 2018).

The green ground plants are affected by the PAHs that are present in the petroleum-containing lands. According to a number of the researchers in this theme a number of theories has been reached to. The first of which is that the plants can absorb the PAHs from the soil by mans of their roots and deliver them to the other

plant parts before completion of growth of the blossoms and that the absorption rates depend on soil type and the physical state of the hydrocarbonic materials. The second theory argues that the plant part above the ground contains a higher percentage of PAHs than the underground part because the percentage of PAHs rising in the air that is adsorbed outside leaves higher concentrations of PAHs in the vegetables that are difficult to remove by washing with cold water as in the case of kale, spinach, and lettuce. The third theory says that the PAHs cause incidence of the toxic effects. However, the forth theory states that the high plants can destroy kinds of hydrocarbons such as benzo(a)byrene. Lastly, it is necessary to perform laboratory studies of the likely biological magnification of these compounds in the terrestrial and aquatic plants (Wenzl et al., 2006).

Controls over, and Toxicity Limits of, Pollutants in Fruits and Vegetables

Controls over toxic compounds have been adopted in many countries for protection of the consumer from their hazardous effects as they – the countries- all have the right and the responsibility for protecting the citizens from the harmful effects which the undesirable substances in the foods may cause. Among these substances are the micotoxins. The FAO Food and Nutrition Paper 81 has been employed to excerpt controls over the micotoxins that are directly used for fruits, vegetables, nuts, and the manufactured foods like juices, beverages, and children's foods, in addition to the other foods produced from fruits and the spices; the origin of many of which is vegetables. Many countries has put controls and criteria for the micotoxins and polluting substances in the foods, especially the fruits and vegetables. The Codex Alimentarius Commission (Codex), WHO, and FAO specified limits for the added and polluting materials in the foods, as well as the trace heavy metals and hydrocarbons that are of importance in settling conflicts in these field products (Hillers, 1999). Within this context, Table 2 illustrates the toxicity limits for some toxic compounds in sorts of fruits and vegetables and in their products.

Table 2: Toxicity Limits of Pollutant Compounds in some Fruits and Vegetables and in their Products

Substance	Pollutant	Limit	Reference
Raw Field Pistachio, peanuts, and other foods for direct human consumption	Total AFs	20 µg/kg	(Smith *et al*., 2016)
Dried vine fruit and soluble coffee	Ochratoxin A	10 µg/kg	(Smith *et al*., 2016)
Apple Juice and Drinks	Patuline	50 µg/kg	(Paster and Barkai, 2011)
Fruits and Vegetables	The hydrocarbons B(a)A, B(b)F, B(k)F, D(h)A, D(h)P, D(i)P, I(c)P, and CHR	2 µg/kg	(Wenzl *et al*., 2006)
Vegetables; Cabbage; Leaf Vegetables; Herbs (Weeds); Mushroom; Potatoes.	Hg, Pd, and Sn	0.1 mg/kg	Food Safety (2009)
	Cd	0.05 mg/kg	
Fruit Juices; Concentrated Fruit Juices.	Hg, Pb, Cd, and Sn	0.05 µg/kg	Food Safety (2009)
Fruits and Vegetables	Cu	10 mg/kg	Ismail *et al*. (2011)
	Zn	100 mg/kg	

References

[1]. Al-Haddad, A.A., Hussain, H. Z. and Fayyadh, M. A. (2016). Evaluation of some physical means efficiency in degrading Aflatoxin B1 in some dry fruits. Arab Journal of Plant Protection, 34(2): 148-155. (In Arabic).

[2]. Al-sayyed Yousof, M. K. (2015). Healthy food and vegetable and fruit pollution. Assiut Journal of Environmental Studies, Issue 42, 15 pages. (In Aabic).

[3]. Andrews, J. H., and Harris, R. F. (2000). The ecology and biogeography of microorganisms on plant surfaces. Annual Review Phytopathology, 38, 145–180.

[4]. Anh, S. A. (2013). Prevalence and distribution of parasites contamination for some type fruits and vegetables in Al-Diwaniya City. Dhi Qar Science Journal, 3(4), 57-64. (In Arabic).

[5]. Barth, M.; Hankinson, T. R.; Zhuang, H. and Breidt, F. (2010). Microbiological Spoilage of Fruits and Vegetables. Compendium of the Microbiological Spoilage of Foods and Beverages, Food Microbiology and Food Safety, ISBN 978-1-4419-0825-4. Springer-Verlag New York, 2010 :135-183.

[6]. Bigdeli, M. and Seilsepour, M. (2008). Investigation of metals accumulation in some vegetables irrigated with waste water in Shahre Rey-Iran and toxilogical implications. American-Eurasian J. Agric. And Environ. Sci., 4(1): 86-92.

[7]. FAO (1995). Fruit and vegetable processing, Chapter 2, General properties of fruit and vegetables; chemical composition and nutritional aspects; structural features, FAO Agricultural Services Bulletin No.119 Rome, Italy.

[8]. Fernández-Cruz, M.; Mansilla, M. L. and Tadeo, J. L. (2010). Mycotoxins in fruits and their processed products: Analysis, occurrence and health implications. Journal of Advanced Research, 1: 113–122.

[9]. Food Safety (2009). Mercury, Lead, Cadmium, Tin and Arsenic in Food, toxicology factsheet series, issue No. 1.

[10]. Golan,R .B and Paster ,N.(2008). Mycotoxins in Fruits and Vegetables, pp. 351.

[11]. Gómez-Govea, M.; Solís-Soto, L.; Heredia, N.; García, S.; Moreno, G.; Tovar, O. and Isunza, G. (2012). Analysis of microbial contamination levels of fruits and vegetables at retail in Monterrey, Mexico. Journal of Food, Agriculture & Environment, 10 (1): 152-156.

[12]. Hassan, Z. H. and Purwani, E. Y. (2016). Microbiological aspect of fresh produces as retailed and consumed in West Java, Indonesia. International Food Research Journal 23(1): 350-359.
[13]. Hillers, V. (1999). Guidelines for using manure on vegetable gardens. Washington State University Food Safety 2: 24 -25.
[14]. Ismail, F.; Anjum, M. R.; Mammon, A. N. and Kazi, T. G. (2011). Trace metal contents of vegetables and fruits of Hyderabad retail market, Pakistan Journal of Nutrition, 10(4): 365-372.
[15]. Jan, A. T; Azam, M.; Siddiqui, K.; Ali, A.; Choi, I. and Rizwanul Haq, Q. M. (2015). Heavy Metals and Human Health: Mechanistic Insight into Toxicity and Counter Defense System of Antioxidants. International Journal of Molecular Sciences, 16: 29592–29630.
[16]. Kumar, N.; Pathera, A. K.; Saini, P. and Kumar, M. (2012). Harmful effects of pesticides on human health. Annals of Agri-Bio Research, 17 (2): 125-127.
[17]. Lintas, C. (1992) Nutritional aspects of fruits and vegetables consumption. In: *Les fruits et légumes dans les économies méditerranéennes: Actes du colloque de Chania* . Lauret, F. (ed.). Mon tpellier : CIHEAM . *Options Mediterraeennes*, 19, 79-87.
[18]. Mathur, A.; Joshi, A. and Harwani, D. (2014). Microbial Contamination of Raw Fruits and Vegetables. Internet. Journal of Food Safety, Vol.16: p.26-28.
[19]. Moss M.O (2008). Fungi, quality and safety issues in fresh fruits and vegetables. Journal of Applied Microbiology, 104:1239–1243.
[20]. Moustafa, K. (2018). Chemical fertilizers in agriculture: Uses and misuses. Arabic Science Archive: 1-12. (In Arabic).
[21]. Papa, S.; Cerullo, L.; Di Monaco, A.; Bartoli, G. and Fioretto, A. (2009). Trace elements in fruit and vegetable, environmental quality, 2: 79-83.
[22]. Paris, A.; Ledauphin, J.; Poinot, P. and Gaillard, J. (2018). Polycyclic aromatic hydrocarbons in fruits and vegetables: Origin, analysis, and occurrence. Environmental Pollution, Vol. 234: 96-106.
[23]. Paster, N. and Barkai, R., (2011). Mycotoxins in Fruits and Vegetables, p. 71, 76, and 78. (Translated book).
[24]. Rather, I. A., Koh, W. Y., Paek, W. K., & Lim, J. (2017). The Sources of Chemical Contaminants in Food and Their Health Implications. Frontiers in pharmacology, 8:830.
[25]. Saeed, S. W. M.; Misha'l. K. E.; Al-Abbadi, M. J. I. and Abdol-Hadi, E. (2016). The Scientific Awareness Bulletin (Micotoxins and their hazards). The Biological Research Unit, pp. 1-18. (In Arabic).
[26]. Shewfelt, R.L. (1990). Sources of variation in the nutrient content of agricultural commodities from the farm to the consumer. Food Quality, 13 (1): 37-54.
[27]. Shotaywiy, M. (2002). Effect of poisons on human health and safety. Assiut Journal of Environmental Studies, Issue 23: (93-114). (In Arabic).
[28]. Smith, M. C.; Stéphanie Madec, Coton, E. and and Hymery, N. (2016). Natural Co-Occurrence of Mycotoxins in Foods and Feeds and Their in vitro Combined Toxicological Effects. Toxins, 8 (94): 1-36.
[29]. Thompson, H.C. and Kelly, W.C. (2003). Vegetable Crops. 5th Edn. New Delhi: McGraw Hill Publishing Company Ltd; 199067. Türkdogan MK, Kilicel F, Kara K, Tuncer I, Uygan I. Heavy metals in soil, vegetables and fruit in the endemic upper gastrointestinal cancer region of Turkey. Environ Toxicol Pharmacol., 13(3): 175-179.
[30]. Wenzl, T.; Simon, R.; Kleiner, J. And Anklam, E. (2006). Analytical methods for Polycyclic Aromatic Hydrocarbons (PAHs) in food and the environment needed for new food legislation in the European Union, Trends in Analytical Chemistry, 25(7): 716-725.

Ashraf O. Khashroom. "Chemical and Microbial Environmental Contaminants in Fruits and Vegetables and their Effects on Health: A Mini Review." IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT) 13.4 (2019): 70-76.