

Aflatoxin in Fresh Produce Supply Chains in Pakistan: Review and Way Forward

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Summary: Pakistan is an agriculture based economy and horticulture is an important industry of this sector. Fresh produce export contributes significant amount of resources to National Gross Domestic Product. However, with increasing food quality and safety awareness amongst the consumers in high end international and domestic markets, and the lack of capacity on behalf of growers and traders to cater the needs of the well-deserved fresh produce consumers is resulting in loss of export markets for the fresh produce industry of Pakistan. Prevalence of aflatoxins in fresh produce commodities at the time of consumption is one of the growing food safety concerns. While some of the published research has established that aflatoxins are found in fresh produce commodities grown in Pakistan and marketed in Arab countries, Europe, and in domestic markets, only limited and random scientific research supports the evidence of presence of the specific quantities and types of aflatoxins in specific fresh produce commodities. There remains a need to conduct a supply chain focused comprehensive research study on assessment of aflatoxins in the major fresh produce commodities of Pakistan.

Key words: Aflatoxins, Assessment, Fruit, Markets, Orchard, Vegetable.

Introduction

Importance of Fresh Produce Industry for Pakistan

Pakistan is an agricultural economy. Agriculture contributes more than 20.9% to the country's Gross Domestic Product and provides employment to 45% of the total labour force of the country [1]. Horticulture is an important sub-sector of the agricultural economy of Pakistan and Government has declared it as one of the priority areas of the agriculture sector. According to the Ministry of National Food Security and Research (MNFSR), the total area under fruits and vegetables (including potato crops) was 1.2 million hectares, with fruits and vegetables sharing around 68% and 32% during 2012-2013, respectively [2]. During the same year, country produced 12.5 million tonnes of fruits and vegetables, in which fruit shared 6.5 million tonnes (52%) and vegetables (including potato) 6.0 million tonnes (48%). Furthermore, Pakistan exported about 1.0 million tonnes of horticulture produce (8.3%) during 2012-2013 and earned foreign exchange of US\$ 639 million [2].

Horticultural crops offer more prospects than other agricultural crops due to their high yield potential and net return per unit area, and being highly labour intensive, create more employment opportunities. The horticulture sector is continuously playing this important role due to the fact that Pakistan has all the basic natural resources like diverse climatic zones, fertile lands, vast plains, four distinct seasons, and well established irrigation system, which allow production of a range of

horticultural crops throughout the year [1]. The country has also got the position, both geographically and strategically to enhance its fresh produce exports to traditional markets like Middle East, Afghanistan, Iran, and the emerging markets like China and Central Asian Republics along with the highly competitive but lucrative markets of Europe and Far East.

More than 80% of the growers of fresh produce in Pakistan are small land holders. They produce fruit or vegetable crops to sustain their lives. Main fruit crops include apple, banana, citrus, dates, guava, and mango. Pakistan also produces good quality apricot, grapes, peach, pear, and plum. Among important vegetables and spices are chillies, garlic, onion, potato, tomato, and a range of leafy and other vegetable crops [1].

Postharvest Pathogens of Fresh Produce Commodities

Fruit and vegetables have been reported as an integral part of the healthy way of life [3] and Pakistan is fortunate enough to be able to produce a variety of fresh produce and export to regional and distant export markets. Postharvest losses in fruits (75%) [4] and vegetables (>40%) [5] are the major constraints for the development of the fresh produce industry in Pakistan. Postharvest losses in fresh produce are mainly due to poor harvesting methods, physical damage, compression, poor packaging material, contact of plant materials with soil and

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infected containers, unhygienic handling of the produce and poor storage conditions [6]. All these factors can potentially cause bruising or physical injury to the produce which ultimately can lead to the fruit rots due to fungal pathogens.

Postharvest rots in fresh produce are caused by several pathogenic fungi [7]. These include *Aspergillus flavus*, *Aspergillus niger*, *Aspergillus parasiticus*, *Curvularialunata*, *Fusarium moniliforme*, *Rhizopusnigricans*, and *Trichoderma viride* [8]. *R. nigricans*, *C. lunata*, and *F. moniliforme* are highly pathogenic and rapidly disintegrate the fruit and vegetable tissues these attack; *A. niger* and *C. capsici* are moderately pathogenic; and *A. flavus*, *A. parasiticus*, and *T. viride* are slow pathogenic. Furthermore, the *A. flavus* is involved in production of aflatoxins in fruit and vegetables [9].

Aflatoxins in Fresh Produce Commodities

'Aflatoxin' is made up of three words; 'a' represents the genus *Aspergillus*, 'fla' represents the species *flavus*, and toxin means poison [10]. These have been reported in several fruit and vegetables [11] including apple, chillies, citrus, corn, dates, fig, grapes, papaya, tomatoes, and even in wine extracted from red grapes. Aflatoxins do not easily disintegrate and its traces have been reported in urine of consumers of fruit containing aflatoxins [12]. The aflatoxins are highly reactive and health hazard for human being and identified in World War II when the masses of Russian army fell sick due to consumption of mouldy food [13]. The army men suffered from multiple diseases including dermal necrosis and haemorrhages. Later on, aflatoxins were considered the reason of death of over one hundred thousand poult in England [14]. Food borne aflatoxins can potentially modify DNA and ultimately can lead to cell death. The rate of tissue destruction can multiply if the host is a patient of Hepatitis B [15].

Bakirdere *et al.* [10] reviewed the incidents of health issues due to aflatoxins and reported 18 different types of aflatoxins. Five most common and human health hazard aflatoxins are B1 and B2, G1 and G2, and M1 [16]. Although aflatoxins are generally considered a problem due to postharvest handling of the commodities [17], however, their growth on intact fruit samples has also been reported [18]. Both pre- and post-harvest solutions are available for the management of aflatoxins below the human health hazard threshold levels [19]. Most of the countries (such as Australia, Canada, and China etc.) do not have aflatoxins standards for fresh fruits and vegetables that is why data from USA were presented in Table-1 (Adapted from Karov *et al.* [20]). Maximum allowable aflatoxins levels in Europe and Africa (in 10 parts per billion, ppb) were

given in Table-2 (adapted from Otsuki *et al.* [21]).

Table-1: Treatment Requirements of Fresh Fruits and Vegetables (Karov *et al.*, 2009).

Commodity	Eligible countries	Eligible production
	Requiring Treatments	Requiring Treatments
	Percent	percent
Fruits		
Apples	90	91
Avocados	18	88
Banana	0	0
Grapes	89	94
Lemon and Lime	4	21
Melon	0	0
Orange	50	93
Peaches	60	97
Pears and Quinces	86	98
Pineapple	1	18
Plums	80	99
Strawberries	0	0
Vegetables		
Asparagus	4	41
Carrot	0	0
Cauliflower and Broccoli	1	1
Celery	0	0
Corn	0	0
Cucumber	0	0
Lettuce	6	52
Onions and shallots	0	0
Pepper	6	8
Potatoes	0	0
Tomato	2	5

Source: Authors' calculation from USAD, APHIS Fresh Fruit and Vegetable Import Manual and USDA, FAS US Trade Internet System.

Table-2: Maximum Allowable Aflatoxin Levels in Europe and Africa (ppb) (Otsuki *et al.*, 2001).

Country	Commodity	Afla toxin B1	Aflatoxin B2
Austria	All foods	1	na
	Mailing and shelled products and derived food	2	na
Belgium	Groundnuts	5	na
	Denmark	Groundnuts	2
Finland	brazil nuts	2	4
	dried figs	2	4
France	all foods	na	5
	all foods	10	na
Germany	Groundnuts	1	na
	Wheat meal	3	na
Greece	Wheat bran	10	na
	Vegetables oils, cereals, wheat meal	5	na
Ireland	all foods	2	4
	Enzyme	na	0.05
Italy	nuts and edible seeds	5	10
	dried fruits	5	10
Luxembourg	all foods	5	30
	dried figs	5	10
Netherlands	Spices	20	40
	Groundnuts	5	na
Portugal	all foods	5	na
	ground nuts	25	na
Spain	all foods	5	10
	all foods	na	5
United Kingdom	nuts, dried figs	na	4
	Groundnuts, copra, palm-kernel, cotton seed	20	Na
Norway (EEA)	all foods	na	5
	brazil nuts	na	5
Africa	mixed foodstuffs depending on animal	50	na
	Groundnuts	14	44

Source: FAO (1995)

At pre-harvest stage, adaptation of good agricultural practices can minimize the occurrence of aflatoxins in fresh produce. At postharvest stage, certain interventions in fresh produce handling system can reduce the incidence of aflatoxins. Furthermore, even if the incidence of aflatoxin causing fungi happens, commercial treatment of Ozonation [22] can manage the affect to a minimal level [23]. Biological control [14,24], chemical detoxification [25] and irradiation [26] are also reported as potential solutions to reduce the occurrence of aflatoxins in fresh produce fruits and vegetables. Timely harvesting, proper drying, sanitation, storage under suitable conditions and protection against insects are also used to minimize aflatoxin risks. Biological and chemical control, detoxification, genetic resistance, surveillance and awareness creation are other strategies that can be used for this purpose [27-28].

Aflatoxins in Fresh Produce Commodities in Pakistan

Incidence of aflatoxins in fresh produce has been repeatedly reported from Pakistan [14, 29-31]. For example in chillies, it was detected eight times higher concentration than the limit accepted by European standards (10 µg/kg) [32]. Aflatoxins are detected in some fruits and vegetables through thin layer chromatography (TLC) but their levels were not reported yet in Pakistan (Table 3 Adapted from Sahar *et al.* [14]).

Higher limits of aflatoxins have resulted in ban of export of identified fresh produce commodities to the high end international markets. For instance European Union banned the import of chillies from Pakistan due to the same issue [33]. Aflatoxins are also reported in Pakistan in coriander, cucumber, tomato, persimmon, peach, and pumpkin [14] (Table 3).

Table-3: Qualitative analytical of Aflatoxin in fruits and vegetables samples by TLC (Sahar *et al.*, 2009).

S. No.	Name of sample	Name of sample Analyzed	Observation	Types of aflatoxin
1.	Tomato	3	Aflatoxin	B ₁
2.	Potato	2	*ND	ND
3.	Peas	4	ND	ND
4.	Beet Roots	3	ND	ND
5.	Pumpkin	4	Aflatoxin	G ₁
6.	Garlic	3	ND	ND
7.	Ginger	3	ND	ND
8.	Onion	3	ND	ND
9.	Chillies (powder)	4	Aflatoxin	B ₁
10.	Carrot	2	ND	ND
11.	Coriander (dry)	3	Aflatoxin	B ₁
12.	Cucumber	3	Aflatoxin	B ₁
13.	Grapes	3	ND	ND
14.	Pomegranate	3	ND	ND
15.	Persimmon	3	Aflatoxin	G ₁
16.	Peanuts	4	Aflatoxin	B ₁
17.	Dates	3	ND	ND
18.	Peach	3	Aflatoxin	B ₁

*ND(Not Detected)

Based on findings of the international researchers in other commodities, it is generally

agreed by the researchers in Pakistan that aflatoxins are produced in fresh produce commodities due to poor storage conditions and retail in open, hot, and humid climate in certain cities of Pakistan. Humidity and air temperature also cause contamination risk in fresh commodities. For example, critical levels of ochratoxin A were observed in berry wine after 20 days of storage under humid air conditions and fungal growth and ochratoxin A did not result in critical levels of ochratoxin A concentration in wine at 21°C [34].

Weak concept of supply chain management in fresh produce industry in Pakistan is a potential hazard for identification of the right stage of infestation of aflatoxins in horticultural commodities [35]. A supply chain in fresh produce industry would be considered the connection of interlinked vertical sequence of businesses working together to cater a segment of consumers. Hassan [36] identified that each single link in the fresh produce supply chain has a role to play in overall quality of the produce delivered to the consumers.

Aflatoxin management is becoming a basic requirement of the high value fresh produce supply chains in Pakistan. Health conscious consumers in international as well as domestic markets are increasingly concerned about the issue of aflatoxins. More export markets may also be lost with increasing awareness of food safety. The small scale farmers have no concept of what exactly aflatoxins are and what, if anything, they can do to manage the issue. There is little concept of SPS compliance. Not even a single vegetable farm in Pakistan has got Global GAP certification. The fruit farms which have obtained international certifications also do not yet qualify the safety aspect of food in terms of freeness from aflatoxins. The status of aflatoxins for major fresh produce of Pakistan (at local level) in whole of the commodity supply chain context, starting at the input supplies and ending at the consumers' kitchens, have never been assessed and reported.

Future of 'Through the Supply Chain' Research on Aflatoxins in Fresh Produce Commodities

Keeping in view the importance of horticulture industry for Pakistan, and because the health of the local and international consumers of fresh produce of Pakistan is being compromised; there is an urgent need to conduct a 'through the supply chain' assessment of aflatoxins in selected fresh produce in Pakistan.

If aflatoxins are found in the existing fresh produce handling system in the supply chains; research studies should be conducted to find

biological control intensive solutions for management of aflatoxins. Collaboration would be made amongst the government institutes and private sector stakeholders to conduct a joint research on this important issue of the industry.

Isolated facilities for research on aflatoxins are available in Pakistan [33]. One of the existing facilities may be strengthened or a new fully equipped and functional facility may be established to meet the international standards of a research facility maintained to conduct research of fresh food based aflatoxins.

Different pre- and post- harvest management strategies for aflatoxins have been reported in literature for the tropical and subtropical fruit and vegetable commodities, including some of the commodities of commercial interest of Pakistan. However, the exact strains of the aflatoxin prevalent in the commercial fruit and vegetables of Pakistan and their respective control / management approaches suitable in the local climatic and geographical conditions of Pakistan are not known. Hence, a thorough understanding of the specific nature and extent of aflatoxins in fresh produce supply chains would be determined by conducting scientific studies.

A baseline survey is suggested for assessment of the nature and severity of aflatoxins in selected fresh produce supply chains by conducting the strain isolation and characterization of commodity specific aflatoxins. The commodities may be selected by the economic importance of the particular commodities for the country and / or with consultation and consensus of the commercial and public sector stakeholders of horticulture industry of Pakistan.

Once the severity of aflatoxins in specific fresh produce commodities in Pakistan is identified, research studies may start with genetic screening of the existing commercial varieties for selection of resistant species [37]. Protocols for management / control of aflatoxins in fresh produce supply chains would be made commercially available as soon as the research findings would be concluded so that the commercial stakeholders can get benefit of their engagement in the project. The research findings would also become available for wider fresh produce industry as soon as the results are commercially tested with the project partners.

The relevant stakeholders and industry at large should be trained for adoption of Good Agriculture and Postharvest Product Handling practices [19], infrastructure can be established in field for early detection and prevention of the

aflatoxin causing pathogens, and awareness among the consumer groups to consume healthy and safe food by eating fresh and green vegetables [38-39]. The program must also consider the capacity building of government institutes and commercial supply chain stakeholders in management of the aflatoxin in fresh produce supply chains in Pakistan.

This approach would help small producers get higher economic returns from marketing of their 'safe' fruit and vegetable products; and consumers would be more confident of the safety of fresh produce they would consume.

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