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SHORT COMMUNICATION

Incidence of postharvest diseases on 'Kumagai' and 'Pedro Sato' guavas at wholesale markets in Brazil

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ABSTRACT

The time after harvest is characterized by physiological changes in the fruit that favor the occurrence of postharvest diseases, which are often observed only after sale. As a result, the damage resulting from the action of quiescent pathogens can be underestimated. From November to April of the years 2009/2010 and 2010/2011, a survey was conducted to quantify the postharvest diseases in 'Kumagai' and 'Pedro Sato' guavas at two large wholesale markets in Brazil. The incidence of postharvest diseases differed significantly between the two cultivars evaluated. The most frequent postharvest diseases for 'Kumagai' guavas were anthracnose, black spot and fusicoccum rot, ranging in incidence from 23.6 and 31.6%. For 'Pedro Sato' guavas, the most frequent postharvest disease was anthracnose, with an incidence of approximately 72.3%.
Key words: *Psidium guajava*, anthracnose, black spot, fusicoccum rot, quiescent disease.

Brazil is among the world's top producers of guava, and the state of São Paulo is the largest producer in Brazil (Agrianual, 2014). In 2011, guava production in Brazil was 342,528 tons (Agrianual, 2014). Both the internal and external markets are currently experiencing an increased demand for fruit quality, which is important for the expansion of the Brazilian export of fresh fruit.

A large portion of all fresh produce is lost worldwide after harvest. The main causes are physiological (wilting, shriveling, chilling injury, etc), pathological (decay due to fungi and bacteria) and physical (mechanical injury), being these causes in many instances interrelated, i.e. mechanical injury can lead to postharvest decay in many cases. Losses are estimated at 10-50% depending on the product, region and type of technology used in production (Benato et al., 2001; Amorim et al., 2008; Fischer et al., 2008).

The quality of fruits is determined by their physical characteristics and external appearance with an emphasis on size, shape and rind color. Guava is a highly perishable fruit and is, therefore, more susceptible to mechanical damage, including both physiological and pathogenic injury. Such damage can occur both during harvest and in subsequent stages, such as in packing houses, during transportation, and by the grocery wholesaler, retailer and consumer (Chitarra & Chitarra, 2005). According to Carvalho (1994), the average shelf life of guava is three to five days at room temperature.

Although mechanical injuries represent the gateway for typical pathogens, this mode of entry occurs in a smaller percentage in immature fruits relative to ripe fruit. Accordingly, it is possible to observe the occurrence of quiescent diseases during fruit ripening.

Postharvest diseases can be classified as typical or quiescent. Typical postharvest diseases are caused by pathogens that infect the fruits by wound after harvest. *Rhizopus* sp. and *Pestalotiopsis* sp. are examples of typical pathogens. Quiescent infections are caused by pathogens that infect immature fruit prior to harvest. Fruits with quiescent infections remain asymptomatic until maturity, when structural and physiological changes trigger the onset of the disease (Barkai-Golan, 2001). Anthracnose, caused by *Colletotrichum gloeosporioides* and *C. acutatum*, and black spot, caused by *Guignardia psidii* are examples of quiescent diseases and are the main postharvest pathogens of guava fruit (Barkai-Golan, 2001; Martins et al., 2007, Fischer et al., 2011).

The interval between harvest and consumption is necessarily short due to the perishability of the fruit. For this reason, many quiescent diseases cannot be observed at the time of product packaging and shipping (Aulakh & Regmi, 2011). Thus, it is difficult to know the exact extent of damage represented by postharvest diseases in guava fruit.

From November to April of the years 2009/2010 and 2010/2011, a survey of diseases in guava fruit was performed at a large guava wholesaler in CEASA (Campinas, SP, Brazil) and three large guava wholesalers in CEAGESP (São Paulo, SP, Brazil). The samples were collected every fifteen days and each sample was comprised of four guava boxes containing between 11 and 13 fruits.

At CEAGESP, 24 samples of 'Kumagai' and 'Pedro Sato' guavas were assessed, totaling 3,185 and 3,260 fruit, respectively. In the 'Kumagai' samples, 87% of the fruit were collected from 22 different producers in Campinas, 11.5% were collected from two producers in Valinhos (SP) and 1.5% was from a producer in Vinhedo (SP). For 'Pedro Sato' guavas, 46% of the fruit were from 20 different producers in Campinas, 34% were from 9 producers in Valinhos, and the remaining 20% were from a producer in Vista Alegre do Alto (SP).

At CEASA, 24 samples of 'Kumagai' and 'Pedro Sato' were assessed, with totals of 1,573 and 992 fruit, respectively. For 'Kumagai' guavas, 89% of the fruit were collected from two producers in Campinas, and 11.0% were from a producer in Louveira (SP). For 'Pedro Sato' guavas, 67.5% were from two producers of Campinas, 25% were from a producer in Louveira, and the remaining 12.5% were from a producer in Cosmópolis (SP).

'Kumagai' and 'Pedro Sato' guavas were in stage 2 (skin color ranging from dark to light green), corresponding to a hue color of approximately 117^o (Cavalini et al., 2006), as determined using a colorimeter (CR-400, Konica Minolta Sensing).

The fruits were kept in the boxes in which they arrived from the wholesale market, numbered and identified according to their origin, size and variety. The boxes were then wrapped in moistened plastic bags containing a portion of wet cotton to simulate a humid chamber. The boxes were then stored at 25°C in a humid chamber for 24 hours, conditions known to be favorable for the major diseases studied. After 24 hours, the fruits were stored at 25ºC until the end of the experiment.

Beginning with the onset of symptoms, the incidence of postharvest diseases was evaluated every two days for 10 days. If necessary, pathogen identification was aided by light microscopic examination of spores and mycelia. Postharvest diseases were classified as quiescent (anthracnose, black spot and fusicoccum rot) and typical diseases (mucor, *Pestalotia* rot and *Phomopsis* rot) for the two cultivars in both years of evaluation.

The first symptoms observed in both guava cultivars were from quiescent diseases: anthracnose, black spot and *Fusicoccum* rot, in both years. These symptoms appeared after four days of incubation and increased with the days of storage during the ten-day trial for both guava cultivars (Figure 1). With four days of storage, the incidence of postharvest diseases on 'Kumagai' guava ranged between 1.5 to 5.2%, and for 'Pedro Sato' guava ranged between 1.0 to 9.4%.

The most frequent postharvest diseases for 'Kumagai' guava were anthracnose (29.7-31.6%), black spot (27.7-31.6%) and *Fusicoccum* rot (23.6-23.8%) (Table 2). Typical postharvest diseases, e.g. *Pestalotia* rot (*Pestalotia* sp.), *Mucor* rot (*Mucor* sp.), and *Phomopsis* rot (*Phomopsis* sp.) were observed at lower incidences.

Anthracnose was the most frequent postharvest disease recorded in 'Pedro Sato' guavas, with final average values of 74.3% and 70.4% for CEASA and CEAGESP, respectively. The incidences of black spot (23.3% and 30.6%) and *Fusicoccum* rot (17.6 and 21.9%) were lower than the incidence of anthracnose. *Pestalotia*, *Mucor* and *Phomopsis* rots were observed at lower incidences ranging from 0.2 to 3.4%.

The incidence of anthracnose in 'Pedro Sato' guavas in CEAGESP was similar to that registered in a previous study at the CEASA/Bauru wholesale market, of 71.5%

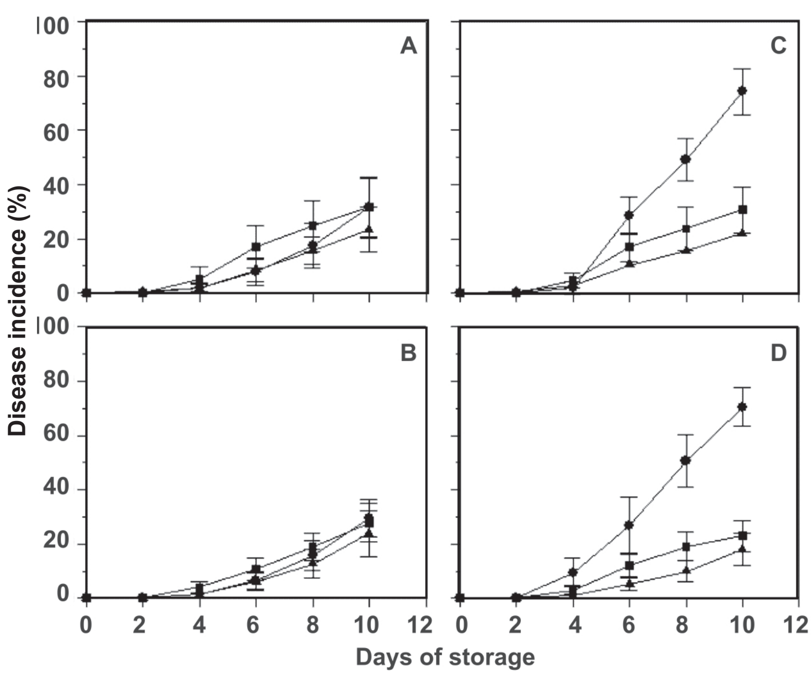

FIGURE 1 - Incidence (%) of the major postharvest diseases (● - anthracnose; ■ - black spot; ▲ - *Fusicoccum* rot) in 'Kumagai' (**A** and **B**) and 'Pedro Sato' (**C** and **D**) guavas, collected every fifteen days from November to April of 2009/10 and 2010 /11 at CEASA (Campinas, SP) (**A** and **C**) and CEAGESP (São Paulo, SP) (**B** and **D**), and kept during 10 days at 25°C. Average data from surveys conducted in 2009/10 and 2010/11. Vertical lines represent the standard error.

(Fischer et al., 2011). The incidences of black spot (4.8%) and *Fusicoccum* rot (4.5%) at the CEASA/Bauru market were lower than those observed in this study.

The guava fruits marketed at CEASA/Campinas and CEAGESP showed a high incidence of postharvest diseases, primarily quiescent diseases. Many studies reporting on guava diseases cite anthracnose as the primary postharvest disease (Gutierrez et al., 2002; Piccinin et al., 2005; Westphalen, 2007; Rozwalka et al., 2008). However, for 'Kumagai' guavas, the incidences of anthracnose, black spot and *Fusicoccum* rot were similar among them and higher than those of the other postharvest diseases. For 'Pedro Sato', anthracnose incidence was the highest, and incidence values were higher than those in 'Kumagai' guavas.

Guavas are generally classified as a climateric fruit (Akamine & Goo, 1979; Singh & Pal, 2008), but some cultivars are non-climateric in nature (Azzolini et al., 2005). The respiration rate of fruit is influenced by many factors such as cultivar, season and maturity. For example, white-fleshed cultivars respire more slowly than pink-fleshed ones (Bashir & Abu-Goukh, 2003; Singh & Pal, 2008), which delays the ripening process and the development of postharvest diseases.

The monthly incidence of each disease varied along the evaluated period, with each disease showing a maximum frequency during one specific month (Tables 1 and 2). At CEASA, the maximum incidence of anthracnose on 'Kumagai' guavas was observed in April (57.6%), maximum incidences of black spot were observed in February and March (46.1% and 43.8%, respectively) and the highest incidence of *Fusicoccum* rot (40.6%) was observed in February. At CEAGESP the maximum incidence of anthracnose occurred in January (39.5%), the maximum incidence of black spot occurred in February and March (35.2 and 35.5%, respectively) and the maximum incidence of *Fusicoccum* rot occurred in January (41.9%) (Table 1).

The maximum incidence of anthracnose on 'Pedro Sato' guavas from CEASA was observed in April (96.7%), the maximum incidences of black spot were observed in November, February and March (38.7, 45.4 and 34.3%, respectively) and the maximum incidence of *Fusicoccum* rot (31.4%) was observed in February. At CEAGESP, the maximum incidence of anthracnose occurred in February (82.7%), the maximum incidence of black spot occurred in March and April (31.4 and 33.1%, respectively), and for *Fusicoccum* rot occurred in January (28.1%) (Table 2).

In contrast to the overall averages, the monthly averages showed differences between the incidences of the major diseases. Most likely, the variation in the incidence of the diseases evaluated in different months of the year occurred because the fruits in each collection originated from different producers, with varied crop management and environmental conditions prevailing at each site. The intensity of postharvest diseases is directly proportional to the duration between harvest and consumption, and the occurrence of disease is influenced by the predominant environmental conditions during this period (Awad, 1993). In addition to the environmental conditions, factors such as the inoculum density, plant management, plant nutrition, and physiological state of the fruit at harvest can directly influence the later development of disease by reducing the inoculum source or by inhibiting infection (Majumdar & Pathak, 1989; Schroeder, 2004).

Variability in the incidence of decay as a function of time and samples of guava was also observed by Martins et al. (2007), most likely due to the environmental conditions at each month of sampling, as the frequency and intensity of diseases are strongly influenced by environmental variation

TABLE 1 - Incidence of post-harvest diseases (%) in 'Kumagai' guavas collected at CEASA and CEAGESP, and stored for 10 days at 25ºC. Data refer to monthly averages of the disease and the overall mean for the evaluated months. Average of two experiments performed in 2009/2010 and 2010/2011.

	Postharvest disease incidence (%)						
Disease	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**Mean**
				CEASA			
Anthracnose	36.9	24.0	32.0	25.0	14.2	57.6	31.6
Black spot	14.0	16.9	29.7	46.1	43.8	39.0	31.6
Fusicoccum rot	20.6	22.0	27.1	40.6	21.0	10.1	23.6
Pestalotia rot	7.3	3.1	3.1	0.8	0.0	5.4	3.3
Mucor rot	0.0	0.0	3.1	1.2	2.8	0.2	1.2
Phomopsis rot	2 1	0 0	0 0	0 0	1 4	0 4	0.7
				CEAGESP			
Anthracnose	27.9	24.0	39.5	33.3	26.5	27.1	29.7
Black spot	18.6	17.2	26.3	35.2	35.5	33.3	27.7
Fusicoccum rot	16.0	21.1	41.9	25.5	23.6	14.6	23.8
Pestalotia rot	3.7	1.0	5.1	3.4	2.6	2.6	3.1
Mucor rot	0.4	0.5	0.4	5.3	4.8	0.9	2.0
Phomopsis rot	3.2	0.0	0.2	1.0	0.0	0.4	0.8

TABLE 2 - ncidence of post-harvest diseases (%) in 'Pedro Sato' guavas collected at CEASA and CEAGESP, and stored for 10 days at 25ºC. Data refer to monthly averages of the disease and the overall mean for the evaluated months. Average of two experiments performed in 2009/2010 and 2010/2011.

Disease	Postharvest diseases incidence (%)						
	Nov	Dec	Jan	Feb	Mar	Apr	Mean
				CEASA			
Anthracnose	79.8	58.3	68.7	60.0	82.5	96.7	74.3
Black spot	38.7	20.6	22.0	45.4	34.3	22.5	30.6
Fusicoccum rot	21.3	12.0	23.9	31.4	25.2	17.5	21.9
Pestalotia rot	10.5	3.1	3.5	1.0	1.4	0.8	3.4
Mucor rot	0.0	0.9	0.0	0.6	0.0	0.0	0.2
Phomopsis rot	5.6	0.0	0.0	0.0	0.5	0.0	1.0
				CEAGESP			
Anthracnose	65.9	59.9	78.7	82.7	63.8	71.3	70.4
Black spot	15.4	17.2	21.5	20.9	31.4	33.1	23.3
Fusicoccum rot	7.5	15.1	28.1	15.0	20.9	19.0	17.6
Pestalotia rot	4.1	1.5	1.7	0.2	0.3	1.3	1.5
Mucor rot	0.0	0.0	0.2	0.9	0.6	1.3	0.5
Phomopsis rot	0.9	0.0	0.0	0.0	0.0	0.0	0.2

during all stages of pre and postharvest (Agrios, 1997). As observed by Martins et al. (2007), the current study showed that the highest incidence of black spot in 'Kumagai' guava from CEAGESP occurred in April, and that the highest incidence of *Fusicoccum* rot occurred in November. For 'Kumagai' guavas, the incidences of postharvest diseases were generally higher in January and February, for both wholesale markets. For 'Pedro Sato' guavas, November and January showed higher postharvest diseases incidences at CEASA and CEAGESP, respectively.

The high incidences of postharvest diseases observed on guava fruit and its short shelf life means that guava fruit production technology needs improvement in order to deliver fruit of good quality. In general, postharvest disease is a cumulative process and is expected to be less prevalent at the wholesale market than at the retail or consumer stage (Harvey, 1978) due to the shorter time between the fruit harvest and the fruit ready to be sold at the wholesale market than at the retail and consumer stages. Additionally, because the rind of guava is edible, the presence of an injury makes the product unfit for marketing and consumption (Silveira et al., 2005).

The storage temperature of the fruit (25°C) used in this study is similar to the ambient temperature to which fruits are exposed at wholesale markets, retailers and other businesses. It is expected that the incidence of disease in the market would evolve in a manner similar to that observed in this study. Thus, a large proportion of the fruit evaluated in this study would be ready for consumption within less than four days.

The search for a quality product to meet a more demanding market requires an investment in the logistic processes and rigorous handling between planting and harvest. In response to these demands, food suppliers have implemented stringent quality standard and certification programs. Products unable to satisfy these standards, even if nutritious and safe for human consumption, become discarded, contributing to food losses (Aulakh & Regmi, 2011).

Refrigeration of perishable food products is the most practical way to delay chemical and biological processes such as respiration, ethylene production, and the growth of microorganisms. Because the fruit can remain on the wholesale market for an extended period of time and is subsequently transported to the site where it will be marketed at room temperature, it is beneficial to keep the product refrigerated to increase its shelf life (Barkai-Golan, 2001). According to Jacomino (2000), 'Kumagai' guavas stored at 10 or 12ºC may be retained for 14 days, and those stored at 8ºC may be retained for up to 21 days.

Maintaining a level of freshness from the field to the consumer's table presents many challenges. A grower should not rely exclusively on a single management practice but should integrate a combination of practices to develop a consistent long term strategy for disease management that is suited to the grower's production system and location.

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