



USAID FIRMS PROJECT

# Mango Sector Development Activities and Export Market Trial Shipments

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Author's Name: David Picha

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# Abstract:

A detailed description of the protocols followed at the mango orchards and packinghouses during preparation of the Sindhri marine container trial shipments to the Netherlands is provided. The arrival quality of the fruit is described in detail, along with the comments of the importer on future market opportunities for Pakistani mangoes in the E.U.

The purpose of the report is to document in detail the steps followed in preparing the mango shipment and the resulting condition, appearance, and marketability of Sindhri mango fruit exported by refrigerated marine container to Europe.



# Acronyms

CA	controlled atmosphere
c.i.f	cost, insurance and freight
f.o.b	freight on board
PHDEC	Pakistan Horticulture Development & Export Company
EU	European Union
USAID	United State Agency for International Development
USDA	United State Department of Agriculture



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# Executive Summary

USAID FIRMS Project activities led to significant advancements in the Pakistani mango sector during 2010. A series of production, postharvest care, and market access improvements were initiated by producers who invested in the mango sector improvement 'MUAVAN Program'. Stakeholders who became partners in the MUAVAN Program benefited from the following activities and interventions: support with GlobalGAP certification of production and packinghouse operations; harvesting equipment and supplies; major improvements in on-farm packinghouse, cooling, and cold storage infrastructure; market linkages with major European mango importers; and trial shipments of fresh and dried mangoes to new market destinations in the U.K. and E.U. MUAVAN Program participants receive a packing line and hot water treatment equipment capable of processing 1 ton of mango fruit per hour, blast chilling equipment capable of cooling 5 tons of fruit in 5 hours, and a cold storage room capable of holding 25 tons of pre-cooled mango fruit at 12° C. This improved postharvest technology will help mango producers maintain the quality of the fruit, extend the product market life, and access new market destinations not formerly possible without on-farm cooling.

Two mango farms have completed their packinghouses and on-farm postharvest infrastructure and were beneficiaries of the initial trial shipments to the U.K. and E.U. in the summer of 2010. An additional 13 mango farms are slated to become beneficiaries of the MUAVAN Program inputs in 2011. The packing equipment and cooling/cold storage facilities provided by USAID are matched in financial value of approximately \$147,000 by the grower in the form of land and packinghouse building construction.

The USAID FIRMS Project implemented technical assistance and training on various aspects of mango production, harvesting, and postharvest care to more than 2,700 mango producers from the major mango-growing clusters in Sindh and Punjab Provinces. The efforts of the technical assistance and training programs will help producers increase their mango marketable yield by up to 15 percent. The USAID FIRMS Project has also implemented a comprehensive Global Good Agricultural Practices (GlobalGAP) certification program and up to 15 mango operations are expected to be GlobalGAP-certified before the beginning of the 2011 harvest season.

New high volume potential export market opportunities were identified for Pakistani mango producers interested in expanding their marketing options to include E.U. retail supermarket channels. A USAID FIRMS Project-sponsored trip to participate in the main European fresh produce marketing trade fair, Fruit Logistica, occurred in February in Berlin. The Pakistani mango producers and exporters were introduced to many leading fresh produce import companies and established important business linkages with multiple mango importers. Discussions were held between the potential importers and Pakistani producers/exporters on mango quality requirements, packaging, and future export opportunities. Each of the E.U. importers agreed to receive samples of fruit during the harvest season for evaluation and presentation to their retail sector supermarket clients. The importers stressed the requirement for producers to be GlobalGAP certified and to obtain consistent supplies of high quality mangoes at a competitive price. This necessitates on-farm cooling and cold storage facilities in order to rapidly remove the field heat from the fruit after harvest.

A total of 9 small air sample shipments (20 cartons per shipment) of mature green stage harvested fruit from the three main mango cultivars grown in Pakistan (Sindhri, S.B. Chaunsa, and White Chaunsa) were sent to 3 different importers in the U.K. The Sindhri mangoes ripened in good condition and the importers obtained a favorable impression of the quality of the fruit. The S.B. Chaunsa and White Chaunsa fruit generally ripened in acceptable condition, although exhibited more quality variability and postharvest decay and deterioration.

Three 20-foot marine container trial shipments of S.B. Chaunsa, Fajri, and White Chaunsa fruit were sent to destinations in the U.K. and the Netherlands. The interval between harvest and fruit arrival ranged from 24 to 31 days. One of the U.K. importers received a refrigerated (12° C) 20-foot marine container and another CA-controlled (3.5 % O<sub>2</sub>, 5 % CO<sub>2</sub>, 12° C) 20-foot marine container of S.B. Chaunsa and Fajri, and White Chaunsa fruit, respectively. Another Dutch importer received a refrigerated 20-foot marine container of S.B. Chaunsa and Fajri fruit. The S.B. Chaunsa and Fajri fruit in the CA container arrived in acceptable condition, but during the 7-10 period after arrival the fruit became soft, the skin developed a grayish-green to grayish brown mottled discoloration, and did not ripen to the normal yellow-orange peel color. The S.B. Chaunsa and Fajri fruit sent in the normal refrigerated container arrived in a soft and ready-to-eat state, although the skin color was still green and a significant amount of anthracnose decay was apparent. However, the fruit soon became excessively soft and never ripened to a normal yellow-orange skin color during the 7-10 period after fruit arrival. None of the fruit in either of these two containers was able to be marketed by retail supermarket clients of the importers. A third 20-foot marine container trial shipment of White Chaunsa fruit was sent after the rains had begun in Punjab Province. The late harvest in combination with a lengthy arrival time (31 days), and improperly functioning temperature unit (unable to lower the inside container temperature less than 15° C) resulted in significant amounts of anthracnose, stem-end rot, and excessively soft fruit upon arrival. The entire shipment had to be disposed of after arrival.

- Considerable challenges need to be overcome in the long distance transport of Pakistani mangoes by marine container. However, strong interest remains among the U.K. and E.U. importers who represent mainstream retail supermarkets in receiving Pakistani mangoes in the future. Additional work is required to improve the pre-and postharvest care conditions to allow for successful long distance marine container shipments of mangoes from Pakistan. This work will continue in 2011 and additional marine container shipments are planned for the upcoming year.

# 1. Introduction

The objective of the USAID FIRMS Project mango sector development program is to significantly improve the competitiveness, value, and export market volume of Pakistani mangoes and their value-added products. Significant and sustainable domestic economic impact is expected in terms of farm-gate value, income generation, rural employment, value-added product development, and service provider business activities.

Market diversification is essential for the continued growth of the Pakistani mango sector. This should include both fresh fruit and value-added mango products. Fortunately, there are numerous potential export market opportunities for Pakistani mangoes. The focus of the USAID FIRMS Project first year trial shipments was to begin initial penetration into the extensive E.U. mainstream retail supermarket segment. Four of the leading mango importers in the U.K. and the Netherlands were sent fruit by air and marine container. In order to be competitive with existing mango supply sources, Pakistani growers/exporters interested in export marketing large volumes of fruit will have to transport the mangoes by marine container. Air freight is significantly more costly ( $\geq 130$  rupees (Rs)/kg to the E.U.) and limited in cargo volume capacity compared to sea freight ( $\sim 40$  Rs/kg for up to 20 tons per 40-foot controlled atmosphere marine container). Development of the marine container transport mode will be necessary in order to allow the arrival cost of Pakistani mangoes to be as low as possible. This will help keep the destination market price in a competitive range with other mango supplying countries, which also target the mainstream retail supermarket outlets. Successful penetration of the large-volume European supermarket channel with Pakistani mangoes will enable the sector to export large quantities of mangoes and thereby obtain the maximum domestic economic impact. A major focus of the USAID FIRMS Project will be to improve the pre- and postharvest care practices and transport protocol needed to obtain consistent supplies of high quality marketable mangoes sent by marine container.

Significant interest was established among the major European produce importers in receiving Pakistani mangoes for evaluation and test marketing with their retail supermarket clients. This interest was reinforced during meetings at Fruit Logistica in early February between potential E.U. importers and leading Pakistani growers and exporters. The USAID FIRMS Project market linkage activities continued with multiple trial shipments from late June through mid-September to these importers during the mango harvest season. The volume of fruit sent by air was small and not intended for commercial sale. Arrival quality of Sindhri, Samar Bahisht (S.B.) Chaunsa, Fajri, and White Chaunsa cultivar fruit sent by air was generally good and favorable impressions were made on the importers. The mature green fruit ripened to a normal yellow-gold skin color and the flavor of all cultivars was generally well liked by the importers. However, some concern was expressed about the relatively soft texture of the Pakistani mangoes upon ripening. Supermarket chains prefer firm-textured fruit in order to withstand the rigors of transport, distribution, and handling to their network of retail stores.

The limited volume air shipments ( $\sim 80$  kg per importer) were followed up by several larger volume marine container trial shipments ( $\sim 7$  tons per importer). Two 20-foot normal refrigerated marine containers and one controlled atmosphere (CA) marine container trial shipments were sent to importers in the Netherlands and the U.K. A comparison of regular versus CA marine container transport was particularly important, since CA technology has provided for significant extensions of market life for a number of fruit crops.

The objective of the marine container trial shipments was to determine if the main Pakistani mango cultivar (S.B. Chaunsa) and the late season White Chaunsa cultivar would tolerate long distant sea shipments to the E.U. The transit time to the E.U. approaches or exceeds 3 weeks. It was anticipated there would be adverse quality issues with the fruit upon arrival, since several previous commercial shipments using sea freight to the E.U. were not successful. However, it is imperative to develop sea freight as a reliable mode of transport for Pakistani mangoes to the E.U if the mainstream retail supermarket sector is to be penetrated. The cost of air freight is too high to allow Pakistani mangoes to compete against mangoes from other countries that use sea freight to supply fruit to the mainstream retail supermarkets.

It will take time to develop the marine container mode of transport. Multiple pre- and postharvest conditions must be right in order for the fruit to arrive in marketable condition. This requires careful attention to detail, beginning with proper pre-harvest production practices and continuing after harvest with on-farm cooling and maintenance of the cold chain during transport.

## 2. OBJECTIVES OF THE MONITORING OF TRAININGS

### 2.1 [REDACTED] Farms Trial Air Shipments

Three USAID FIRMS Project-assisted trial air shipments of mangoes were made to the U.K. The fruit was grown at [REDACTED], near Lodhran. The mango cultivars were harvested and prepared in a similar manner. The fruit was transported in an air-condition vehicle to either Lahore or Karachi and exported by F.A. International on Pakistan International Airlines (PIA) passenger aircraft from Lahore or Karachi to London Heathrow International Airport. The fruit was immediately cleared from British Customs and transported by road to the receiving warehouses of three leading mango importers in the U.K. The importers who received the fruit were Univeg, Wealmoor, and Total Exotics. Each of these importers is located in England and has multiple U.K. retail supermarket clients.

The initial trial shipment was made in late June and consisted of sixty 4-kg cartons (240 kg total) of Sindhri mangoes. Twenty cartons each were sent to three of the three different mango importers. The second trial shipment was made in mid-July and consisted of sixty 4-kg cartons (240 kg total) of S.B. Chaunsa mangoes. Twenty cartons each were sent to Univeg, Wealmoor, and Total Exotics. The third trial shipment was made in August and consisted of sixty 4-kg cartons of White Chaunsa mangoes, of which twenty cartons each were sent to the same three importers.

Photos of the fruit arrival condition and quality after ripening of each of the air shipments are included in Annex 1 of this report.

### 2.2 Sindhri Air Shipment

Sindhri cultivar mangoes were harvested on June 23, 2010 in the firm green stage of maturity. Fruit soluble solids content ranged from 6-8° Brix. Fruit pulp temperature was between 35-37° C. The internal pulp color was creamy-white. The mangoes were carefully harvested; with the pedicels remaining intact at a length of about 3 cm. The fruit were placed inside plastic field containers, filled with only one layer of fruit. The containers were placed under shade and brought into the nearby packinghouse within one hour of harvest.

In the packinghouse, the fruit were removed from the containers and the pedicel was carefully cut close to the shoulder of the fruit. The fruit were placed stem-end down on metal de-sapping racks, where they remained for several hours until the flow of latex exuding out of the cut pedicel ceased. The fruit were then sorted and manually graded. A single layer of uniform-sized fruit was packed in a 4-kg open-top corrugated container, imported and manufactured by Arabian Packaging in Dubai. The cartons were put in a 21° C storage room and exposed to 150 ppm ethylene gas to initiate the ripening process. After approximately 2 days, the cartons were transported in an air-conditioned vehicle to Lahore. The fruit was sent from Allama Iqbal International Airport on June

26 on a PIA passenger aircraft to London Heathrow International Airport. The trial shipment arrived on June 27 and following clearance was transported to the importer's receiving warehouse. The trial shipment of Sindhri mangoes allowed the leading British importers the opportunity to observe the appearance, firmness, and edible quality of Pakistan's major early season export cultivar.

### **2.2.1 Fruit Arrival Quality and Importer Feedback**

The fruit arrived in very good condition and the importers held and ripened the green-skinned fruit in their respective warehouse receiving facilities. The fruit kept in cold storage for 7-10 days at 10° C did not turn color, but the fruit held between 15-22° C turned a yellow-green to yellow-gold skin color. The skin color eventually changed to a uniform yellow-gold, which is characteristic of the cultivar.

In general, the fruit ripened well with nice uniform skin coloration, good flavor, and a market life of at least two weeks. Each of the importers was favorably impressed with the quality of the fruit. The only concern expressed by one of the importers was the fruit became quite soft in texture when fully ripe. In general, the importers preferred not to receive mangoes ripened with ethylene. They preferred a slower rate of ripening of the mature green fruit in their temperature controlled storage rooms at about 22° C and high humidity, without exposure to ethylene. The importers preferred the mango fruit to be mature but not ripe upon arrival. Ideally, the skin should have about 20-30 % yellow peel color. Even coloration of the skin must be obtained during ripening.

One of the importers gave the fruit an average rating of 3+ out of 5 on the overall market quality, which included external appearance, pulp color, firmness, and eating quality. Each importer requested additional trial samples of later maturing cultivars for observation and evaluation.

## **2.3 S.B. Chaunsa Air Shipment**

S.B. Chaunsa cultivar mangoes were harvested on July 12, 2010 in the firm green stage of maturity. Fruit soluble solids content ranged from 7-8° Brix and the pulp temperature at harvest was 36° ±2° C. The harvesting and postharvest care practices were similar to those described in the first shipment, except the fruit were not treated with ethylene. The fruit was transported in an air-conditioned vehicle to Karachi on July 15 and loaded into the cargo bay of a PIA passenger aircraft bound for London Heathrow the next day. The trial shipment of S. B. Chaunsa mangoes allowed the leading British importers the opportunity to observe the appearance, firmness, and edible quality of Pakistan's major mid-season cultivar.

### **2.3.1 Fruit Arrival Quality and Importer Feedback**

The fruit arrived in generally good condition and the importers ripened the green-skinned fruit in their respective warehouse receiving facility. The fruit generally ripened well with good skin color and flavor. However, one of the importers indicated the external quality is not what would be expected by their supermarket clients. Shriveling of the peel was apparent on many of the fruit due to excess dehydration and the lack of supplemental humidification during ripening and transport.

This quality constraint can be avoided by holding the fruit in a ripening room maintained at 90-95 % relative humidity. Softening and bruising injury of the tips of the fruit was apparent in some of the cartons. This constraint can be minimized by using a carton liner with cells to stabilize the individual fruit in the carton during transport and distribution.

The internal fruit quality was questionable by one of the importers. The flesh texture was quite soft when ripe and jelly seed was observed in some fruit. Jelly seed is a physiological disorder due to a deficiency in calcium. The S.B. Chaunsa cultivar may be more susceptible to this disorder, and/or soil calcium was deficient. The fruit for future export shipments should be come from areas in the orchard which are free of jelly seed. In addition, the internal flesh color was observed by one of the importers to be lighter than desired when ripe. Uneven “egg-yolking” of the flesh was also noted.

## 2.4 White Chaunsa Air Shipment

A third airfreight trial shipment of White Chaunsa mango fruit from [REDACTED] was sent to the same three U.K. importers in late August. The harvesting and postharvest care practices were similar to those described in the previous shipments. The fruit was not exposed to ethylene gas to stimulate ripening. The fruit was transported to Lahore on August 25 and sent via PIA the next day to London Heathrow. The trial shipment of White Chaunsa mangoes allowed the leading British importers the opportunity to observe the appearance, firmness, and edible quality of Pakistan’s major late-season cultivar.

### 2.4.1 Fruit Arrival Quality and Importer Feedback

The mangoes arrived in the U.K. in very firm condition with a completely green external skin color. Internally, the pulp was a pale white color, very firm, and acidic in flavor. Minor surface scarring and fruit bruising was noted. Sap stains were observed on about 5 % of the fruit.

The fruit arrived in generally acceptable condition, but with more skin injury and defects than the previous air shipments. The importers ripened the green-skinned fruit in their respective warehouse receiving facility. The fruit generally ripened well with good skin color and flavor (19 % soluble solids three days after ripening). However, the incidence of anthracnose and stem-end rot became noticeable on many of the fruit as they ripened. This is unacceptable to retail supermarket clients and detracted from the importer’s impression of the test shipment. In addition, several of the fruit had internal seed germination (vivipary), which was highly undesirable. One of the importers also did not prefer the light yellow internal flesh color of White Chaunsa. A comment made by one of the importers was in comparison with the other two cultivars, White Chaunsa would be least preferred in taste and does not have the flavor profile they are looking for. The White Chaunsa mangoes that did not have anthracnose ripened and stored well. One of the importers indicated it is a very dense fruit and holds its firmness very well when mature. These are all positive characteristics for distribution of mangoes to the mainstream retailers.

One of the importers provided the following summary of the air trial shipments: “I feel the samples we received this year demonstrate that the exporter and grower understand the fruit quality

requirements needed so we can move forward with commercial shipments for the retailers here in the U.K. I sincerely hope we are able to work together in the future. Perhaps the most important barrier to develop the Pakistani mango market is the price that it is possible to deliver product to the UK. Many small Pakistani exporters send low value fruit to the U.K. This sets a low price in specialist stores who handle products that are popular with U.K. residents with family ties to the Pakistan/India/Bangladesh region. This will always be a price comparison with GlobalGAP product, even when in reality the product is quite distinct. A method is needed to overcome this. One method is sea-freight, the costs of which can only be carried by a larger business. Another could be the requirement that strict traceability is required for export permits to be emitted”.

## 2.5 Trial Marine Container Shipments

Three FIRMS Project-assisted trial sea shipments of mangoes were made to the E.U. Two of the shipments were sent to the U.K., using a normal refrigerated marine container and a controlled atmosphere (CA) refrigerated marine container. The shipment sent to the Netherlands was in a normal refrigerated marine container. The fruit used for the trial shipments to the U.K was produced at [REDACTED]. The fruit used for the trial shipment to the Netherlands was produced at [REDACTED], near Rahim Yar Khan. Following packing and cooling, the fruit was loaded into the 20-foot marine containers and transported to Port Qasim. The containers were equipped with a Genset to maintain refrigeration during over-the-road transport. Upon arrival in Port Qasim, the containers were plugged into the electrical power source to maintain refrigeration during the several days of holding at the port. The containers were then loaded onto the deck of the departing vessel within a day of sailing. The shipments were exported by F.A. International using Maersk Lines. The containers destined for the U.K. were off-loaded in Salala, Oman and put on another Maersk Lines vessel destined for the port of Felixstowe, England. The total sailing time from Port Qasim to Felixstowe was 21 days. The vessels arrived in Felixstowe on a Saturday and were not released by British Plant Quarantine officials for at least several additional days. Once released, the containers were transported by road to the receiving warehouse of Univeg, in Spalding, England. The container destined for Barrendrecht, Netherlands was put on a Maersk Lines vessel which sailed directly to the port of Genoa, Italy. The total sailing time from Port Qasim to Genoa was 16 days. After inspection and release of the container from the port, the pallets of mangoes were off-loaded and transferred into another refrigerated vehicle. The mangoes were transported by road to the receiving warehouse of Solfruit, in Barrendrecht, Netherlands.

Photos of the fruit arrival condition and quality of each of the marine container shipments are included in Annex 1 of this report.

## 2.6 [REDACTED] Refrigerated Marine Container Shipment (S.B. Chaunsa and Fajri)

The initial refrigerated marine container shipment consisted of mangoes primarily of the S.B. Chaunsa cultivar, along with a few cartons of Fajri. The fruit was harvested over a 3-day period from July 12-14.

The fruit came from large older trees that had not been given regular pre-harvest fungicide sprays during fruit growth and development. The lack of pre-harvest preventive fungicide sprays will invariably result in a higher incidence of stem end rot and anthracnose fungal spores on the fruit. This will increase the amount of disease pressure on the fruit after harvest and during ripening. In addition, it was observed that some pickers were dropping the harvested fruit on the ground from a height of 3-4 meters or more. Such windfall fruit are subject to bruising injury and skin damage. Other pickers were more careful in their harvesting practices. Nevertheless, constant supervision of the harvesting crew is important in order to avoid rough harvesting practices that will cause bruising and physical damage to the fruit.

The harvested fruit was placed inside plastic field containers, filled with only one layer of fruit. The containers were placed under shade and brought into the nearby packinghouse within one hour of harvest. The fruit were removed from the containers and the pedicel was severed close to the shoulder of the fruit. The fruit were de-sapped by submergence in a 0.5 % lime solution for about 15 seconds and then transferred to a tank of potable water, where they were rinsed and cleaned. The fruit were transferred onto metal tables and left to air dry and complete any additional latex flow emanating from the severed pedicel. The fruit were then put into well-ventilated plastic crates and cooled to 12° C in a cold storage room with circulating air. The fruit pulp temperature cooled to 12° C within about 8 hours after harvest. The mangoes were then manually sorted, graded for size uniformity, and packed in a single layer 4-kg open-top fiberboard carton. Some of the cartons of packed mangoes remained in the 12° C room for 2 days while the harvesting continued in order to obtain enough fruit to fill the 20-foot marine container.

Due to an incomplete loading dock area, the cartons of packed mangoes had to be individually carried from the cold storage room and loaded on pallets inside the marine container. The cartons were stacked 16 layers high, with 9 cartons per layer. Each pallet contained 144 cartons. The stacked cartons were secured on the pallet with 4 corner boards, which were nailed to the base of the wooden pallet. In addition, multiple layers of strapping material were wrapped and tightened around the stacked cartons. Twelve pallets were loaded into the 20-foot marine container, for a total of 1,728 cartons.

The process of hand loading and stacking of the pallets inside the marine container took approximately 7 hours to complete. It was not possible to keep the reefer container temperature below 27° C during the loading process. The reefer container was sealed and departed for Port Qasim at about 7 a.m. on July 16. It arrived at Port Qasim approximately 21 hours later. The container was staged and loaded onto the Maersk Lines vessel which departed Port Qasim at approximately 6 a.m. on July 17, with direct sailing to Genoa, Italy. The vessel arrived in Genoa on August 2 and the marine container was off-loaded from the deck of the ship. After inspection and release of the container from the port, the pallets of mangoes were off-loaded and transferred

into another refrigerated vehicle. The mangoes were transported by road to the receiving warehouse of Solfruit, in Barendrecht, Netherlands, where they arrived in the late afternoon of August 6.

### **2.6.1 Fruit Arrival Quality and Importer Feedback**

The pallets of mangoes arrived in Barendrecht with a considerable amount of carton collapse and fruit damage. This was likely due to a combination of factors, including load shifting during sea transport, loose strapping material, and weak corner boards. The cartons could not be tightly strapped while inside the confined space of the marine container. The cartons should be stacked and the pallets strapped and secured while inside the cold storage room. The entire pallet of stacked cartons should then be moved into the marine container. The lack of pallet stability, load shifting, and somewhat loose packing of the fruit inside the cartons resulted in considerable skin injury to the fruit due to rubbing on the bottom of the carton.

The condition of the fruit upon arrival was fair. Noticeable symptoms of bruising, skinning injury, anthracnose decay, and a mottled gray peel discoloration were evident on at least one-quarter of the fruit in the load. It was estimated that approximately 70 % of the fruit was in marketable condition upon arrival, although the skin was still green. The initial response of the importer upon observing the fruit arrival appearance was “yes, I can sell this mango in Europe”. Although the skin color was entirely green, the mangoes had undergone significant internal ripening in transit. The pulp texture was soft, with an average firmness of 4 lb (1.8 kg) using a 16 mm tip. The sugar content, as measured with a refractometer, increased from 6-8° Brix at the time of harvest to an average of 22° Brix upon arrival. The fruit were ready-to-eat and the flavor was excellent. The mango buyer from Solfruit agreed that S.B. Chaunsa is one of the world’s sweetest and premier eating mangoes. He was very interested in sustained future shipments of Pakistani mangoes.

Although the S.B. Chaunsa flavor was excellent, there were significant arrival quality issues with the fruit. The skin surface appearance was dull and the soft pulp texture was a concern. The majority of mangoes marketed through E.U. retail supermarkets have a glossy surface appearance and very firm texture, but less flavor and a significantly lower sugar content compared to Pakistani mangoes. Varying amounts of bruising injury and mechanical injury to the skin was also noticeable on about 15 % of the fruit upon arrival in the Netherlands. Significant anthracnose fungal decay was also apparent on about 15 % of the fruit.

Additional care must be taken to prevent the flow of caustic sap from the stem end onto the fruit. This occurred on approximately 5 % of the fruit. The importer did not like the dull and somewhat dirty appearance of the fruit surface. The lime wash used for de-sapping may be responsible for some of the dull surface appearance and the water used for removing the lime wash may not have been clean enough. Manual de-sapping of the fruit on de-sapping tables will take more time, but results in a better appearing fruit surface.

The S.B. Chaunsa and Fajri mangoes were not shriveled, but lacked the firmness of a Keitt, Kent, or Tommy Atkins (the leading mango varieties marketed in Europe). Although the fruit was ready-to-eat upon arrival, the importers want to have an additional 7-10 days of market life remaining for the fruit. This is necessary to have enough time to distribute the mangoes to their retail store outlets, in addition to having several more days of shelf display time. It will also take a lot of

market promotion to educate the European consumer that a soft-textured green-skinned S.B. Chaunsa mango from Pakistan is acceptable and has better flavor than Keitt or Kent mangoes.

Securing the fruit inside the carton by placing them on cell-pack tray liners will help minimize vibration, bruising, and softening during transit. Individual Styrofoam sleeves wrapped around the fruit may also help, although many retailers prefer mangoes to be unwrapped.

The high amount of postharvest anthracnose development on the skin of the fruit was a serious concern. This fungal disease is initiated on the tree during fruit development. It can be minimized by proper pruning of the tree and timely applications of preventive fungicides prior to harvest. In addition, a postharvest hot water submergence treatment for at least 3-5 minutes at  $52^{\circ} \pm 0.5^{\circ} \text{C}$  has been shown to significantly reduce the severity of this fungal disease. A 100 ppm concentration of thiabendazole or prochloraz added to the  $52^{\circ} \text{C}$  hot water has a synergistic effect and will improve the control of postharvest decay. Unfortunately, the hot water treatment unit at JDW Orchards was not completed and functioning properly in order to test this procedure at the time of the trial shipment. A postharvest hot water submergence treatment is used to control decay in other mango producing countries. The precise water temperature and duration of submergence in the hot water will have to be tested for the different Pakistani mango cultivars at the firm mature stage of fruit maturation. It is possible that different cultivars may have slightly different optimal water temperature-duration conditions needed for decay control, while at the same time avoiding injury to the fruit.

Some of the fruit was held in the warehouse of Solfruit for observation during the subsequent 7-10 days. Other pallets of fruit were distributed to various potential retail clients for their evaluation. Unfortunately, during the 7-10 period after arrival of the marine container the quality of the mango fruit deteriorated significantly. The incidence and severity of anthracnose decay increased and the skin on the majority of fruit discolored to a grayish-green and grayish-brown mottled appearance. There was no difference in appearance or postharvest decay between S.B. Chaunsa and Fajri fruit. Very few fruit ripened to a normal yellow-gold color. The undesirable skin color, high amounts of anthracnose decay, and soft fruit texture did not meet the quality standards required for marketing mangoes in the mainstream retail supermarkets. The lack of yellow-gold skin coloration was also a concern and an undesirable characteristic for wholesale market buyers who sell mangoes to owners and clients purchasing fruit for ethnic grocery stores. Although some fruit may have been marketable, the expense of manually re-grading and re-packing of the load was too costly to justify salvaging some of the fruit for retail market sales.

A report on the fruit arrival condition and quality from Solfruit is shown in Annex 2 of this report.

## 2.7 [REDACTED] CA Marine Container Shipment (S.B. Chaunsa and Fajri)

The controlled atmosphere (CA) refrigerated marine container shipment also consisted of mangoes primarily of the S.B. Chaunsa cultivar, along with a few cartons of Fajri. The fruit was grown at [REDACTED] and harvested on July 12. The mangoes came from trees that had been given

several preventive fungicide applications during the month prior to harvest. These fungicide treatments helped to lower the incidence and severity of postharvest decay upon fruit ripening.

All of the harvested fruit were de-sapped manually by placing them on de-sapping racks for about 3 hours to allow for completion of the latex flow from the severed pedicel. Following de-sapping, the mangoes were hand wiped with a soft cloth and put in small plastic containers and transferred to the grading table. One highly skilled grader, along with several assistants graded and packed the majority of the 1728 carton load over about an 11-hour period. The mangoes were packed according to size in open-top 4-kg corrugated cartons and then transferred into the nearby 12° C blast chiller room. Following cooling to a 12° C internal temperature, which required about 5 hours, the packed mango cartons were transferred to an adjacent cold room also set at 12° C. The packed cartons remained inside the cold storage room for 1-1.5 days prior to loading the 20-foot CA marine container. The cartons were palletized inside the cold storage room and moved manually by a hand jack inside the CA container. The loading dock area was sealed, which prevented the influx of hot outside air and allowed for maintenance of the cold chain while loading the CA container. The loading process took approximately 2 hours to complete. A total of 12 pre-fumigated wooden pallets of fruit containing 144 cartons per pallet were loaded into the CA marine container. Each pallet had 12 layers of cartons stacked in a 3 x 3 carton configuration per layer.

The CA container was sealed and departed for Port Qasim at about 7 p.m. on July 15. The internal container temperature was set at 12° C, with an atmospheric gas composition of 3.5 % O<sub>2</sub>, 5 % CO<sub>2</sub>, and 90 % relative humidity. The CA marine container arrived at Port Qasim approximately 27 hours later and remained at the Maersk Lines staging area prior to loading onto the departing vessel. The temperature and gas atmosphere composition inside the container were maintained at the desired set values.

The vessel departed Port Qasim on the morning of July 17. The CA container arrived on schedule in Felixstowe on Saturday, August 7. However, it was not released by British Plant Quarantine officials for several days. After release, the container was transported by road to the receiving warehouse of Univeg, in Spalding, England, where it arrived on August 10. The interval between fruit harvest and arrival at the Univeg warehouse was 29 days. This time duration would normally be the limit of the market life of mangoes. However, it was unknown if several additional weeks of market life could be obtained for Pakistani mangoes using CA conditions (low O<sub>2</sub>, high CO<sub>2</sub>) for transport.

### **2.7.1 Fruit Arrival Quality and Importer Feedback**

The fruit quality of the mangoes sent by CA container was evaluated upon arrival. There was little damage to the cartons and pallets. The condition of the fruit was generally very good. It was estimated that about 85 % of the fruit was in marketable condition upon arrival, although the skin color was still entirely green. The skin had essentially no change in color since harvest, about 4 weeks earlier. However, the fruit did ripen internally. The sugar content increased to an average of 21-22 % Brix. The fruit firmness was noticeably softer than at harvest, but not objectionably soft. The fruit arrived essentially in a ready-to-eat stage. The fruit from the CA container were firmer compared to the trial shipment sent by normal refrigerated container to the Netherlands. The fruit from had no incidence of anthracnose decay. However, the skin on some of the S.B.

Chaunsa and Fajri fruit had darkened with noticeable amounts of grayish-green to grayish-brown mottling. This was mostly superficial, but still objectionable.

The fruit surface of the mangoes de-sapped manually was noticeably cleaner and of better appearance than the surface of the fruit de-sapped with lime. Univeg preferred this natural color. They also preferred the fruit not to be waxed or enclosed in a protective sleeve.

The mango buyers for Univeg were very impressed with the flavor and eating quality of the fruit, especially S.B. Chaunsa. However, some reservations were expressed about the lack of fruit firmness, particularly if an additional week or longer is required to complete the marketing process. Transport of mangoes by CA container (3.5 % O<sub>2</sub>/5 % CO<sub>2</sub>) will allow the fruit to maintain its desirable eating qualities upon arrival. Internal pulp color was uniformly light yellow to yellow in most of the fruit, without any noticeable discoloration. The mangoes tolerated the nearly 4 week voyage very well. On a scale of 1-10, with 1 being unacceptable and 10 being perfect, Univeg rated the shipment a 7-7.5 and was very pleased.

Unfortunately, during the 7-10 day period after arrival of the CA container the quality of the mango fruit deteriorated significantly. The amount of skin discoloration and grayish-green to grayish-brown mottling intensified. There was no difference in the degree of discoloration between S.B. Chaunsa and Fajri fruit. Very few fruit ripened to a normal yellow-gold color. The undesirable skin coloration and soft flesh texture resulted in the majority of fruit not meeting the quality standards required for marketing in the mainstream U.K. retail supermarkets. The lack of fruit firmness coupled with the inability of the skin to ripen a uniform yellow-gold color were the major quality issues with this shipment. Anthracnose decay was very minimal in this trial shipment. However, the estimated percentage of marketable fruit remaining in the cartons was very low in the 7-10 day period after fruit arrival. The importer was not able to have any of the fruit marketed by their retail supermarket clients.

A report on the fruit arrival condition and quality from Univeg is shown in Annex 3 of this report.

## 2.8 [REDACTED] Refrigerated Marine Container Shipment (White Chaunsa)

The second refrigerated marine container trial shipment consisted entirely of the late- season maturing White Chaunsa cultivar. The fruit was grown at [REDACTED] and harvested on August 23. Following harvest the fruit were manually de-sapped for several hours, hand wiped with a soft cloth, sorted according to size, packed in 4-kg open-top corrugated cartons, forced-air cooled to 13° C pulp temperature, temporarily held at 13° C, and loaded into a 20-foot refrigerated marine container. A total of 12 pre-fumigated wooden pallets of fruit containing 144 cartons per pallet were loaded into the marine container. Each pallet had 12 layers of cartons stacked in a 3 x 3 carton configuration per layer.

The marine container was transported to Port Qasim on August 25. The internal container temperature was set at 13° C, without supplemental humidification. Upon arrival in Port Qasim, the container remained in the Maersk Lines staging area prior to loading onto the deck of the container ship. The ship departed Port Qasim the morning of August 28 and sailed to Salala, Oman, where the container was off-loaded and transferred onto another Maersk Lines vessel destined for

Felixstowe, England. The ship arrived at the port of Felixstowe on Saturday, September 18. The container was off-loaded, but not released. It remained in the port for 4½ days prior to inspection and release by British Plant Quarantine authorities. It was then transported in-land to Spalding, England, where it arrived at the Univeg warehouse on September 23. The total length of time between harvest and fruit arrival in England was 31 days.

The Ryan recorder temperature monitoring device put in the marine container clearly showed a 15° C temperature during the entire voyage. The temperature was set at 13° C at the time of departure from [REDACTED]. The mangoes were pre-cooled to 13° C prior to loading. In addition, a FIRMS Project staff member accompanied the container to Karachi and verified the container temperature setting was at 13° C at the time of sailing. The location of the Ryan recorder was on top of the pallet about two-thirds back from the front of the container, so it should have been receiving cool 13° C air the entire voyage. It did not, but rather it remained at 15° C. Unfortunately, the temperature inside the marine container did not cool below 15° C during the entire transit period. This resulted in an undesirable acceleration of fruit ripening, significant postharvest deterioration, and poor fruit quality.

### **2.8.1 Fruit Arrival Quality and Importer Feedback**

The fruit arrived in over-ripe and unmarketable condition. Essentially the entire load had to be disposed of, since the majority of fruit in each carton had significant deterioration, decay, and were excessively soft. The high amount of pre-harvest fungal inoculum on the fruit surface, the undesirably high transit temperature inside the marine container (i.e. 15° C), and the lengthy duration between the August 23 harvest and September 23 arrival at destination (i.e. 31 days) were all responsible for the poor arrival quality and unmarketable condition of the mangoes.

The heavy rains in the Punjab Province growing area prior to harvest resulted in high amounts of anthracnose and stem-end rot fungal disease contamination on the fruit surface. The incidence and severity of anthracnose and stem end rot on mango fruit are always higher during rainy conditions. The fungal spores exist on the fruit surface in a dormant state and generally do not develop until some days after harvest. Temperatures above 13° C will result in higher amounts of postharvest decay, with the degree of severity dependent on the temperature and concentration of fungal spore inoculum.

The majority of fruit were excessively soft upon arrival. After a month of transport at temperatures in the range of 12°-15° C, all cultivars of Pakistani mangoes will lose firmness and become soft. The 15° C temperature inside the container coupled with the 31 day duration between harvest and arrival of the fruit is too high a temperature and too long a duration for mangoes to have any market life remaining. Even at 13° C transit temperature, a 1-month period between harvest and arrival at the destination market is pushing the postharvest life of mangoes.

Interestingly, the grayish-green to grayish-brown peel discoloration which developed on the fruit in the two earlier trial shipments at 12° C also occurred on some of the fruit sent at 15° C. A temperature of 15° C is above any previously reported chilling injury-inducing temperature for mangoes. Therefore, the lack of normal yellow skin coloration and the development of grayish-brown mottling on the peel is not likely due to chilling injury. Excessively high ambient temperatures prior to harvest (i.e. ~45° C) could have caused heat stress injury to the fruit and

irreversibly damaged the metabolic processes responsible for normal skin pigmentation. Another possible explanation of the grayish-brown discoloration of the skin during ripening could have been vibration injury to the fruit during transit. Cellular damage beneath the skin may have resulted in internal solute leakage and oxidation, eventually expressed as a darkening of the peel.

## 3. Findings and Recommendations

### Pre-Harvest Disease Control Recommendations

Two of the most important diseases of mango in Pakistan are anthracnose, caused by the fungus *Colletotrichum gloeosporioides*, and stem-end rot, caused by several different fungi (*Dothiorella* spp., *Lasiodiplodia theobromae*, *Phomopsis mangiferae*). These diseases can attack flowers, young fruits, leaves and twigs. They are also the two worst postharvest diseases of mature mango fruits, negatively impacting the market quality. The infection process begins on the tree when the fruit are developing. The fungal spores often remain dormant on the surface of the mature green stage fruit, but rapidly develop and penetrate the surface of the weaker and softer yellow skin as the fruit ripens. Disease development is accentuated by rainfall or heavy dews.

Symptoms of anthracnose appear as black, slightly sunken lesions of irregular shape, which gradually enlarge and cause fruit rot. Symptoms of stem-end rot appear as a darkening of the skin around the base of the pedicel of the harvested fruit. The infected area may enlarge rapidly to form circular brownish-black areas of water-soaked tissue which can extend over the whole fruit within several days.

Reduction in the incidence and severity of anthracnose requires a combination of proper cultural practices to avoid the build-up of high levels of disease inoculum. These practices include proper tree spacing to avoid crowding, proper pruning of the interior of the tree to allow more air movement through the canopy, pruning of defoliated branch terminals and mummified inflorescences during the growing season, removal of fallen leaves under the tree, and regular preventive maintenance applications of appropriate fungicides to the tree beginning at the first appearance of the panicles when flower buds begin to expand and continuing up to harvest. In order to avoid excess residues on the fruit, the appropriate spray interval between the last fungicide application and harvest must be taken into account depending on the chemical applied and the destination market. The interval between fungicide sprays should be in the 10-14 day range in order to reduce the disease pressure. Fungicides which provide control of anthracnose on mango include azoxystrobin, carbendazim, chlorothalonil, ferbam, mancozeb, and prochloraz. Rotation of fungicide applications is recommended and more than two consecutive applications of the same fungicide should be avoided. During rainy periods, prochloraz provides better control of anthracnose, but it is not effective against stem-end rot. It is also important that the fungicide applications are done during the relatively cooler morning hours to avoid fruit abortion. The application dosage depends on the fungicide formulation and should always follow label instructions. Examples of effective application dosages include 500g of mancozeb per 200 liters of water and 800 ml of chlorothalonil per 200 liters of water.

### Harvesting Practice Recommendations

Mango fruit are very delicate and must be carefully harvested and handled gently. Any minor bruise damage or injury to the skin will result in postharvest decay. Harvest should be done during the coolest part of the day, as more bruise damage will occur with increasing pulp temperatures. Mangoes should not be picked during rain as postharvest decay will be significantly higher.

Mangoes are harvested manually and should be cut or clipped from the tree, leaving at least 3 cm or longer of the pedicel attached. This is necessary to prevent latex flow from the point of detachment. If allowed to drop onto the fruit surface, latex will cause an undesirable blemish and burn the skin. The fruit should be handled gently (like eggs) at all times to avoid bruising. Fruit should not be allowed to drop to the ground, as it will result in severe impact bruising, mechanical injury, and surface scarring.

The recommended harvest tools include knives, clippers, or poles with a sharp-edged cutting blade attached at the end. Fruit which can be reached from the ground is easily harvested using a knife or clippers, while fruit higher up in the tree is removed with the special poles. A canvas pouch or nylon net bag is attached to a metal ring below the sharp-edged cutting blade at the end of the pole to catch the detached fruit. The pouch should be large enough to hold several fruit. After detachment, the fruit should be carefully lowered to the ground and placed in a well-ventilated rigid plastic field container with the pedicel oriented upwards. Only one or two layers of fruit should be put in the field container and it should be placed in a shaded area to avoid sunburn to the fruit. The fruit should be carefully transported to the packinghouse as soon as possible after harvest.

### **Postharvest Handling Recommendations**

After arrival in the packinghouse, the pedicels should be re-cut to a length of several millimeters extending past the shoulder of the fruit. The cut stem area should be oriented downward on a de-sapping rack to prevent latex exudation onto the fruit surface. After several hours, the latex flow will cease and the fruit can be cleaned, graded, and packed. An alternate de-sapping procedure is to submerge the fruit in 0.5 % lime solution ( $\text{CaCO}_3$ ), followed by a clean water rinse. Further incubation on de-sapping racks may be necessary to complete the de-sapping process.

Once the sap flow has ceased, the fruit should be cleaned manually with a damp cloth or mechanically using cleaning and grading equipment. A hot water and fungicide treatment ( $52^\circ\text{C} \pm 0.5^\circ\text{C}$  for 3-5 minutes, depending on cultivar) may be necessary if the incidence and severity of postharvest disease is high. Following this treatment, the fruit are dried, sorted, and graded according to size and condition. The fruit should be packed into strong, well-ventilated containers for market. An open top 4-kg corrugated carton containing a single layer of mango fruit is the carton most preferred in the U.K./E.U. mainstream retail export market. The carton should have a minimum bursting strength of 275 lb/in<sup>2</sup>. The carton should be properly labeled to include the following: GlobalGAP certification number, traceability code, name of product, variety, net weight, grade, size, country of origin, and name and address of the exporter or consignee. Individual mangoes can be wrapped with foam sleeves or placed on cell-pack liners inside the carton to cushion the fruit and minimize surface abrasions during transport. The cartons should be stacked closely together on a wooden pallet and tightly secured with corner boards and multiple layers of strapping material. Avoidance of load shifting on the pallet is essential to prevent carton collapse and injury to the fruit during transit.

The perishable nature of the mango requires removal of field heat to a pulp temperature of  $12\text{-}13^\circ\text{C}$  using a blast chiller or forced-air cooling as soon as possible after harvest in order to preserve fruit market quality. This must be followed by storage at  $12\text{-}13^\circ\text{C}$  and maintenance of the cold chain during transport and distribution to market. The optimal postharvest storage and transport conditions for Pakistani mangoes are  $12\text{-}13^\circ\text{C}$  and 90-95 % relative humidity.

## Hot Water Treatment

Reduction in the incidence and severity of anthracnose and stem-end rot can be obtained by submergence of the fruit in a  $52^{\circ}\text{C} \pm 0.5^{\circ}\text{C}$  hot water bath for 3 to 5 minutes. The optimal submergence time depends on the amount of disease inoculum present and the mango cultivar. Disease control is more effective if a fungicide is added to the hot water. For example, carbendazim will provide control against stem-end rot and thiabendazole is effective against anthracnose. The proper fungicide active ingredient concentration shown to be effective is in the 100 ppm range, although this will vary with the amount of fungal inoculum on the fruit. The type and amount used will also depend on the importing country residue tolerances.

It is important to remember that postharvest treatments will not provide complete disease control. Proper pre-harvest tree pruning, field sanitation, and fungicide applications are also necessary. In addition, the harvested fruit must be cooled promptly following harvest and maintained at the recommended  $12^{\circ}\text{C}$ - $13^{\circ}\text{C}$  temperature.

The packing lines and hot water treatment units being installed by Technology International were not operational at either JDW Orchards or [REDACTED] at the time of the trial shipments. The temperature controller was not able to maintain the required  $52^{\circ}\text{C} \pm 0.5^{\circ}\text{C}$  temperature range of the hot water bath. Furthermore, the initial design of the hot water treatment unit did not result in complete submergence of the mango fruit in the hot water tank, which is a requirement for disease suppression. Therefore, it was not possible to use the hot water units and conduct a thorough test of the different hot water treatment temperatures. However, a limited number of mangoes were able to be submerged in the hot water tank for 3 minutes at  $52^{\circ}\text{C}$ . An additional small amount of fruit was manually submerged in a thiabendazole fungicide. The temperature of the fungicide solution was not able to be maintained at  $52^{\circ}\text{C}$ . The fruit condition was monitored upon arrival in the U.K. There was no noticeable difference in the mango fruit condition or decay incidence between non-hot water and non-fungicide treated fruits and the hot water/fungicide treated fruits.

A series of hot water and postharvest fungicide treatment tests are planned for the 2011 trial shipments.

## Summary Flow Chart Steps of Fruit Handling from Harvest to Export Market Arrival

The following mango care steps will be required by growers and exporters in order to provide export markets with consistent supplies of high quality mangoes.

### Pre-harvest Production Practices

Annual tree pruning following harvest.

Removal of dead leaves, debris, and fruit from underneath tree canopy.

Regular preventive maintenance fungicide applications every 10-14 days from flower bud growth until harvest.

### Harvesting Practices

Gentle and delicate harvesting of the fruit.

Leave stem attached, approximately 3 cm long.

Avoid dropping of fruit onto the ground.

Put fruit in rigid, well-ventilated plastic harvest container, 1 layer deep.

Keep fruit and harvest containers under shade.

Carefully transport harvest containers to packinghouse.

### Packinghouse Practices

De-sapping.

Cut off stem near fruit shoulder, followed by positioning fruit upside down to the stem end.

Let sap slowly finish flowing, typically requiring 2-3 hrs if done manually on racks

An alternate de-sapping procedure is to submerge the fruit in 0.5 % lime solution ( $\text{CaCO}_3$ ), followed by a clean water rinse.

Clean fruit manually with a damp cloth after de-sapping.

Hot water and fungicide treatment ( $52^\circ\text{C} \pm 0.5^\circ\text{C}$  for 3-5 minutes, depending on cultivar).

Fruit drying

Sorting and grading of fruit according to size and condition.

Pack into 4 kg corrugated cartons for export market.

Stack cartons on wooden pallet.

Blast cooling of fruit to  $12\text{-}13^\circ\text{C}$  pulp temperature.

Temporary cold storage at  $12\text{-}13^\circ\text{C}$ , 90-95 % relative humidity.

### Transportation Practices

Loading of pallets into pre-cooled marine container maintained at  $12\text{-}13^\circ\text{C}$ .

Transport of marine container to Port Qasim.

Loading of marine container onto deck of sailing vessel.

Departure to export market destination.

### **External Heat and Chilling Injury**

Mangoes are susceptible to heat stress injury while still on the tree. Exposures to temperatures above 40°C for extended periods of time may result in uneven ripening and a mottled skin. Exposure of the fruit to even several hours above 46° C will cause heat injury, with the symptoms expressed as skin scald, blotchy coloration, or uneven ripening. Heat stress injury while the fruit were still on the tree may have been the cause of lack of skin coloration following arrival of the S.B. Chaunsa fruit in the U.K. and Netherlands in the marine containers. Daytime temperatures in the 45-47° C range did occur in the Punjab Province mango growing regions during June and July prior to fruit harvest.

Mango fruit are also highly sensitive to postharvest chilling injury, which is a physiological disorder occurring at temperatures below 11°C. Symptoms of chilling injury include pitting and sunken lesions on the skin, uneven skin coloration, internal darkening of the pulp, off-flavor development, and decay. The amount of chilling injury is a function of temperature and time, with lower temperatures and longer durations of exposure causing more injury.

### **Anticipated Future Export Volume**

Pakistan produces around 1.4-1.6 million metric tons of mangoes annually. Approximately 5-7 percent of the total production volume is exported. Barring unforeseen agro-climatic or international economic constraints, it is anticipated the Pakistani mango export industry will continue to grow in upcoming years. Technical assistance and training to growers, improved on-farm packinghouse and postharvest infrastructure, and new market linkages created by the USAID FIRMS Project will help support the increased export market growth. However, it will take several years to make significant in-roads in penetrating mainstream retail supermarkets in the E.U. and other export destinations. Successful arrivals by sea to long distance markets are still in the development stage. Few growers and exporters are willing to risk sending S.B. Chaunsa and White Chaunsa by marine container to Europe. In addition, the E.U. importers who purchase mangoes for the mainstream retail supermarkets will require time to gain confidence in the ability of Pakistan to supply consistent supplies of high quality mangoes. It is not a foregone conclusion that Pakistani mangoes will arrive in good condition by marine container and have an additional 7-10 day market life after arrival. Considerable research and development work still needs to be done. In addition, growers must use excellent pre- and postharvest care practices to minimize the incidence of anthracnose and stem-end rot and provide optimal temperature management of the fruit.

An average annual mango export volume growth of between 5 to 10 percent during 2011-2013 is a realistic and achievable goal, barring unforeseen weather calamities in Pakistan and/or a global

economic downturn. Strengthening of existing and development of new export market linkages will continue through the life of the FIRMS Project.

### **Perspective Future Markets for Pakistani Mangoes**

Historically, Pakistani mango exporters have sent the majority of the export volume to wholesale markets in the Middle East, with the U.A.E., Saudi Arabia, Kuwait, Oman, and Bahrain collectively receiving about 75 % of the total annual export volume. Only about 12 % of the total Pakistani mango export volume is sent to Europe, with the U.K. receiving approximately 10 % of the export volume and continental Europe receiving 2 %. All of the Pakistani mangoes exported to Europe are marketed through lower valued wholesale channels, in contrast to higher-valued retail channels. Sales of Pakistani mangoes are targeted mainly to the local Pakistani and Indian expatriate communities. There has never been any presence of Pakistani mangoes in the mainstream E.U. supermarket retail stores, which collectively constitute the majority of all consumer food purchases in most E.U. countries. Penetration of this high-value and high volume market channel represents a significant challenge to Pakistani mango growers and exporters. The E.U. retail supermarket trade represents the best opportunity for market expansion and diversification. This market outlet could potentially receive in the thousands of metric tons of Pakistani mangoes, with an economic impact worth millions of dollars of revenue and thousands of jobs being created in Pakistan.

Pakistani mango growers/exporters have not been able to provide consistent supplies of export market quality fruit that the large retail supermarkets can rely on. Development of sustainable export market relationships with the major European, Asian, and North American retail supermarket chains is necessary for the Pakistani mango sector to realize significant export market growth and domestic economic impact. In order to be price competitive against other countries which supply mangoes to export markets during similar months as Pakistan, sea freight will be required as the primary mode of transport. FIRMS Project activities will continue to be directed to the development of successful export market arrivals using marine container transport. Reliance on air freight as the only mode of transport will not allow for major expansions in the volume of Pakistani mango exports. This is due to the high cost of air freight and the current limited cargo volume space available on passenger aircraft.

The USAID FIRMS Project will continue with trial shipments and market linkage establishment between growers/exporters and potential mango importers in additional export market destinations (i.e. U.A.E., Gulf countries, Singapore, Malaysia, Indonesia, Hong Kong, China, Australia, E.U., and North America).

Significant export market opportunities exist in the neighboring countries of Iran and China and these market destinations should be fully explored. However, both countries require pre-certification and a hot water treatment of the fruit for insect disinfestation prior to export. The protocol is similar, but not exact, to the USDA hot water submergence treatment protocol for mangoes (i.e. 46.4° C for 65-90 minutes). This hot water treatment procedure is different than the short-term treatment used for postharvest disease control. Currently, there are only two hot water treatment facilities, both located in Karachi, that have the capability to be certified for mango exports to Iran or China.

India represents a potential market destination for late-season harvested White Chaunsa fruit. The mango harvest season in India overlaps Pakistan in the early and mid-season, but typically finishes prior to the White Chaunsa cultivar harvest in mid to late August.

Japan and Australia represent good future export market destinations for Pakistani mangoes. Japan has little domestic mango production and the late-May through September market availability for Pakistani mangoes is counter-seasonal to the Australian harvest. However, both countries have strict phytosanitary requirements and stipulate that mango imports must be subject to a vapor heat treatment. Currently, no such facility exists in Pakistan.

### **E.U. Mango Market Situation and Prices**

Although mangoes comprise only a small percentage of the total fresh fruit market in the E.U., demand for this sub-tropical fruit is increasing in nearly all the E.U. member nations. The vast majority of mangoes consumed in Europe are imported. Spain is the only E.U. country which produces mangoes in significant volumes, with an annual production of about 20,000 metric tons. The mango import volume into the 27-member E.U. was approximately 210,000 tons in 2008, with an import value of import value was €270 million (Eurostat). Pakistan supplied 4.6 % of E.U. mango imports in 2008. Mango import volume into the E.U. increased 8 % annually in the 10-year period between 1999 and 2008. Since 2002, E.U. imports of mangos have increased by more than 50%. However, the recent global economic downturn several years ago has had a negative impact on the mango market expansion.

Mango consumption in the E.U. has historically been the highest in the U.K., followed by the Western European nations of France, Germany, and the Netherlands. In the U.K. and many Western European countries the mango has graduated from an exotic fruit available only seasonally, to a mainstream fruit available on a year-round basis. Consumer demand for new mango cultivars and ready-to-eat mangoes is increasing. As consumers get more acquainted with mangos, preferences are shifting from colored, fibrous cultivars to better flavored, green-yellow skinned, less fibrous cultivars, with superior eating quality. This bodes well for the future market potential of Pakistani mangoes.

In terms of consumption markets, the U.K. and France have the highest per capita consumption of mangoes. This can be attributed to the large population of ethnic minorities in these countries, who facilitate market penetration. Germany and the Netherlands are the other leading mango importing countries in the E.U. The Netherlands is also an important re-distributor of mangos to the rest of the E.U.

The majority of mango purchases in the E.U. are made via retail supermarket channels. For example, in the U.K. approximately 80 % of the total mango purchases are made in retail supermarkets. Unfortunately, Pakistani mangoes have never had a market presence in the mainstream U.K. and E.U. supermarkets. Development of this market channel represents a significant opportunity for Pakistani growers and exporters.

E.U. supermarkets purchase large volumes of mangoes, but require consistent supplies of high quality fruit at competitive prices. The size range of mangoes preferred for the retail supermarket trade generally ranges from 275-550 gm per fruit (5 to 14 count per 4-kg carton). Retailers require

the mangoes to be uniform in appearance, firm in texture, and free of postharvest decay. Consumers are looking for aesthetically appealing, superior eating quality fruit.

The average E.U. FOB (port of entry) import price range for Kent, Keitt, and Tommy Atkins mangoes (main cultivars marketed in E.U.) is \$1-\$1.50/kg from April through mid-September. The E.U. import price for premium quality cultivars (similar to premium quality Sindhri, S.B. Chaunsa, or White Chaunsa) ranges from \$1-\$2.50/kg. However, E.U. FOB market price for premium quality cultivars from late September through November can reach \$3/kg. The economics of exporting Pakistani mangoes to the E.U. can be very favorable, especially if the lower cost sea freight transport mode can become reliable.

The retail supermarket price of Pakistani mangoes will vary according to country, fruit size, competing supply sources, market demand, overhead, and desired profit margin of the retailer. However, the retail price of mangoes charged to the consumers in retail supermarkets is not of primary significance to the Pakistani grower or exporter, since he will be paid on either the f.o.b. Pakistan price or the c.i.f. country of destination price.

### **U.S. Mango Market Situation and Prices**

Market opportunities for Pakistani mangoes also exist in the U.S. and Canada, but there is more competition and the transport cost to send fruit to these distant world markets is very high. The U.S. is the world's largest mango importing nation and represents a significant market opportunity for Pakistani mangoes if sea freight technology can be perfected. The majority of the mango fruit marketed in the U.S. is imported, with only small volumes of production in Puerto Rico, Florida, California, and Hawaii. Total mango production in the continental U.S. has remained limited over the past few years at an estimated 3,000 metric tons annually. On the other hand, imports of mangoes into the U.S. have increased by an average of 6 percent annually over the past decade. Mexico is the dominant supplier of mangoes to the U.S., providing approximately 160,000 tons of mangoes annually to the 280,000 ton annual U.S. mango import market. The average per capita consumption of fresh mangoes in the U.S. has quadrupled since 1990, to an estimated 1 kg per year in 2008. However, mango consumption is relatively low when compared to other tropical fruits such as bananas (11.8 kg) and pineapples (2.3 kg), indicating room for future growth.

The cost of air freight is too high to allow large volumes of mangoes from Pakistan to penetrate the U.S. market. The harvest season of neighboring Mexico directly overlaps that of Pakistan and high quality mangoes are sent by truck to the U.S., with a typical U.S. arrival market price of \$1.00-1.50 per kg. This price is less than the air freight cost alone from Pakistan. Nevertheless, high priced niche markets will exist for small volumes of Pakistani mangoes sent by air. However, the fruit must be able to withstand the USDA-required irradiation treatment and arrive in acceptable market condition. This has not yet been proven and will take at least several years of research and development work to determine if this is possible for the various cultivars of Pakistani-grown mangoes. The high cost of irradiating and exporting mangoes to the U.S. by air will not allow for substantial export volumes to penetrate the U.S. market. Few consumers will be willing to purchase mangoes at a retail cost of \$3.00 or more per fruit, which has been the case for recently enterable Indian mangoes in the U.S. market. In fact, India only exported a total of 95 metric tons of mangoes to the U.S. in 2010. As in the case of the E.U. market, it will be imperative to use less expensive sea freight transport if Pakistani mangoes are to be sold in large quantities to

mainstream North American (U.S. and Canada) retail supermarkets. Interestingly, the marine container transport time from Port Qasim to the northeastern U.S. is similar to that of the U.K. and northern Europe. Therefore, continuation and improvement of marine container trial shipments to the E.U. have very important implications for the development of the mango market for Pakistani fruit in both European and North American retail market channels.

It is highly recommended the FIRMS Project devotes significant resources to continued trial shipments of Pakistani mangoes by marine container to distant export market destinations. The interest level remains very high in receiving Pakistani mangoes in Europe and this will likely be the case for North America. However, all of the importers are careful to point out that the mangoes must arrive with a 7-10 day additional market life and at a price that is affordable to the middle class consumer. Air freight is not an option for large volume imports to the mainstream retail supermarkets. Supermarkets are under increasing pressure to maintain affordable retail prices for their products. This typically requires c.i.f purchase mango prices in the range of \$1.00-\$2.00 per kg, depending on the market destination, competing supply sources, and market demand.

### **Certification and Phytosanitary Requirements for Export Markets**

GlobalGAP certification is a requirement for all growers intending on exporting mango fruit to the mainstream E.U. supermarkets. In addition, individual importers and supermarkets may have their own set of ethical and social-responsibility requirements which will need to be met. GlobalGAP certification is currently not required by importers selling fruit in the wholesale markets.

### **Collaborator Contacts for Trial Shipments**

The U.K. is the leading importer of mangoes among the 27 member nations of the E.U. The following 3 companies are the main importers and suppliers of mangoes to the U.K. retail supermarket sector. They have a diverse client base including all the main supermarket chains.

[REDACTED]

The Netherlands is the second most important importing country of mangoes into the E.U. Solfruit is a leading importer of mangoes for the Dutch and continental European market. Solfruit supplies mangoes to two leading retailers in Germany and the company has a strong distribution presence in the Scandinavian countries as well as Eastern Europe.

Solfruit International B.V.

Handelsweg 120

2988 DC Ridderkerk

P.O. Box 56

2990 AB Barendrecht

Netherlands

Contact: Mr. Gustavo Rodriguez

Telephone: 31-180-693-500

The company F.A. International was the export firm which handled all the documentation and logistics for the air and marine container trial shipments. The professionalism and service provided was excellent. Sincere gratitude and thanks are extended to [REDACTED] for the good work and cooperation he provided in making the trial shipments flow smoothly.

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

## 4. Conclusion

The USAID FIRMS Project, in cooperation with private and public sector stakeholders, has made significant progress in strengthening the Pakistani mango sector since implementation efforts began over a year ago. The most noteworthy achievements include: 1) the initiation of improved on-farm packinghouse equipment and cooling/cold storage infrastructure; 2) the establishment of multiple market linkages between Pakistani growers/exporters and the leading mango importers in the U.K. and E.U. who procure fruit for the major supermarket chains; 3) trial shipments by air and sea to these importers; 4) GlobalGAP certification of multiple mango farms; 5) grower training and technical assistance in proper mango production and harvesting practices. These achievements are very positive accomplishments for the long-term expansion of the Pakistani mango industry. The lack of proper postharvest care and cooling infrastructure has always been a major limitation to the maintaining fruit quality after harvest and thereby reducing the export market price and competitiveness of Pakistani mangoes.

The beneficial impact of FIRMS Project activities on the mango sector will continue to expand. Continuing the trial shipment activities during the upcoming harvest seasons is necessary, not only to Europe, but to additional destinations in the Gulf region, Asia, and North America. The trial shipments will focus on overcoming the challenges to obtaining commercially acceptable and economically profitable marine container shipments in a diversity of export market destinations, including Dubai, Indonesia, Malaysia, Singapore, Australia, Hong Kong, China, Canada and the U.S. Leading mango importers in multiple market destinations will be familiarized with high quality Pakistani mangoes for future commercial export shipments.

Many lessons were learned from the trial shipments and it is recognized that considerable pre- and postharvest improvements in the supply chain will be necessary in order to provide consistent supplies of high quality Pakistani mangoes in the U.K., E.U., and other international market destinations. Sea freight is the mode of transport that will allow for large volumes of Pakistani mangoes to be exported and landed in the destination countries at competitive prices.

The initiatives of the FIRMS Project Mango MUAVAN Program have laid the foundation for transformational changes in the Pakistani mango sector. Significant economic investments have been made for the first time in modern on-farm postharvest cooling infrastructure and packinghouse equipment. The growers who have invested in these infrastructure improvements will now be in a position to provide the market with consistent supplies of high quality fruit. The lack of on-farm cooling and refrigerated storage capacity has always been one of the most significant constraints to the expansion of the mango export industry. In addition, the MUAVAN Program-funded postharvest technology improvement facilities are multi-crop and multi-purpose facilities. They can be used for preparing a diverse range of fruit and vegetable crops for market. The on-farm cooling and cold storage facilities will provide growers important infrastructure for extending the market life of numerous other horticultural crops.

The interest level remains high among the major E.U. mango importers in receiving consistent supplies of high quality GlobalGAP-certified Pakistani mangoes for marketing in the mainstream retail supermarkets. Significant export volumes to retail market channels in the E.U. and other

closer proximity destination countries are possible. However, this will require numerous improvements in pre-harvest cultural practices and postharvest care. The most important improvements needed are annual tree pruning and size maintenance to allow for good internal canopy penetration of pre-harvest fungicides, regular applications of the proper pre-harvest fungicides to reduce the inoculum level of anthracnose and stem-end rot fungal diseases, careful harvesting and handling practices to avoid bruising and mechanical injury of the fruit, thorough de-sapping to prevent latex burn of the peel, forced air cooling and cold storage infrastructure to remove the fruit field heat as soon as possible after harvest, maintenance of the cold chain during temporary on-farm storage and transport of the fruit to the destination market, and strong, well-ventilated packaging to eliminate physical injury to the fruit.

## 5. Annexes

### Annex A: Photos of Mango Fruit from Harvest to Export Market Arrival



Figure 1: Conveyor feeding belt and washing unit (left), hot water submergence tank (center), and blast chiller (right) were used to prepare the trial shipment fruit.



Figure 2: Cream to light yellow pulp color of Sindhri fruit at harvest.



Figure 3: Manual fruit harvesting practices (left, center) and rigid plastic field container (right).



Figure 4: Manual de-sapping of Sindhri mangoes.



Figure 5: Unloading (left) and manually packing (center) of mango fruit into 4-kg open-top cartons (right).



Figure 6: Carton weighing (left), pallet formation (center), and blast chilling (right) of mangoes.



**Figure 7: Manual loading of pallets by hand jack into the 20-foot marine container.**



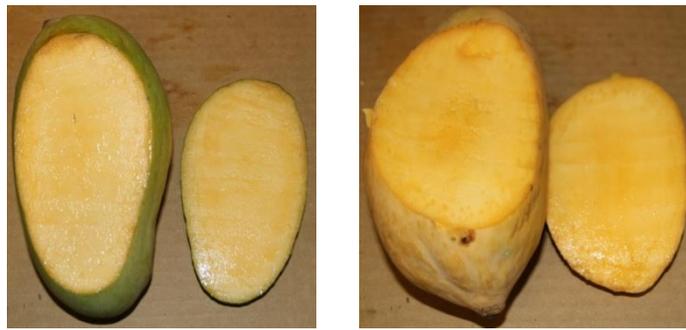
**Figure 8: Arrival (left) and departure (right) of the refrigerated 20-foot marine container used to transport mangoes from the on-farm packinghouse to the Netherlands.**



**Figure 9: Lower carton collapse (left) and pallet shifting during transit required re-stacking of all the cartons at the Solfruit warehouse (right).**



**Figure 10: External appearance of Sindhri mangoes upon arrival in the Netherlands, 21-22 days after harvest**



**Figure 11: Internal appearance of Sindhri mangoes upon arrival in the Netherlands, 21-22 days after harvest**



**Figure 12: Soft textured Sindhri mangoes with a pulp firmness reading of 3.7 lbf for green skinned fruit (left) and 1.4 lbf for yellow-orange skinned fruit (right).**



Figure 13: Hand-held digital refractometer used to measure °Brix (% sugar) of mango fruit.



Figure 14: The wide range in fruit maturity in each carton masked any postharvest fruit quality difference between treatments.





Figure 15: Representative cartons of fruit from the different postharvest treatments.



Figure 16: Widely spaced boards on the pallet surface resulted in carton collapse immediately after palletization (left, center). Carton collapse became worse during transit, resulting in multiple losses of cartons upon arrival in the Netherlands (right).



**Figure 17: Significant fruit weight loss occurred during transit; with the final gross carton weight falling well below 4.0 kg.**



**Figure 18: Fruit shriveling and peel desiccation was noticeable on multiple fruit upon arrival.**



**Figure 19: Improper or incomplete de-sapping results in latex exudation from the severed stem onto the fruit skin, causing noticeable blemishes (left, center) and anthracnose decay (right).**

## Annex B: Solfruit Arrival Quality Report ( [REDACTED] )



### FRUIT CONDITION REPORT – RECEIVED BY SOLFRUIT INTERNATIONAL BV

#### CONSIGNMENT INFORMATION

<b>Date of arrive</b>	07-07-2011	<b>Reference Solfruit</b>	PTN-10-002709
<b>Supplier:</b>	<i>Firm</i>	<b>Vessel:</b>	Maersk Madrid
<b>Container:</b>	MWCU 580070-0	<b>Ryan Recorder 1614697</b>	With respect to the transit temperature we can report that a Ryan recorder not had been placed in the container
<b>Product:</b>	Mangoes Origin Pakistan	<b>Variety:</b>	<i>Sindhri</i>
<b>Brand(s):</b>	<i>Hyder Shan fruit Farm</i>	<b>Category</b>	Cat I
<b>Amount of pallets:</b>	12	<b>Amount of cartons</b>	1728
<b>Amount of inspected pallets:</b>	12	<b>Amount of inspected cartons</b>	60

#### TEMPERATURE & PACKING INFORMATION

<b>Pulp Temperature</b>	Between 13.4 and 14.9 degrees	<b>Packaging</b>	Open top cartons
<b>Ryan Temperature</b>	15 degrees celcius	<b>Palletizing Bad</b>	The cartons had been loaded on one way wooden pallets. The pallets had been strapped by means of vertically applied straps
<b>Transport claim</b>		<b>Gross Weight per carton</b>	4 kg
<b>Size</b>	6-7-8-9-10 ers	<b>Tarra</b>	360 gram
<b>Growers</b>	Hyder Shan Fruit Farm	<b>Nett Weight per carton</b>	6er = 3.53-3.70 7er = 3.06-3.53 8er = 3.43-3.48 9er = 3.53-5.55 10 = 3.41-3.68

#### PRODUCT OBSERVATION

<b>Texture consistency</b>	Sensitive to soft
<b>Ripeness &amp; Maturity</b>	Ripe very ripe lbs pressure form 0 to 4 lbs
<b>Brix Readings</b>	16.3% to 18.2%
<b>Eating Quality</b>	Good ready to eat
<b>External Colour</b>	Greenish yellow undertone to yellow
<b>Internal Colour</b>	Yellow
<b>Internal Defects</b>	Not found
<b>External Defects</b>	We unpacked and inspected contents of a representative number of cartons taken at random and we noted as follows : Resin skin damage 15% Scab 8% Bruising 22% bottom layers
<b>Decay</b>	Yes 3% Stem –end rot 15% pressure decay in the bottom layers from the pallets

#### CONCLUSIONS

<b>Quality Score (from 1-5)</b>	.3/4
<b>Necessary Actions</b>	<ul style="list-style-type: none"> <li>The consignment has to be claim by the supplier for decay and ripeness.</li> <li>Remark has to be make for space between the pallets and frond of the container all the pallets</li> </ul>

are slanting.

- Different pallets has mould and all the pallets bottom layers are damage.
- All the pallets has to be repack and marketed on rapid way because the ripeness.
- Pictures included.

1= Excellent

2= Good

3= Regular (part of the consignment is showing problems, quality report has to be considered as a (partial) claim)

4= Poor (the entire consignment is showing serious problems, quality report has to be considered as a claim)

5= Total Loss (the consignment has to be destroyed, quality report has to be considered as a claim)

**Solfruit International B.V.**

**Handelsweg 120**

**2988 DC Ridderkerk**

**The Netherlands**

**Quality Control / Bernard Fitskie**

**Tel.: 0031(0) 641469883**

**Fax: 0031(0) 180693598**

**Tel: 0031(0) 180693597 Direct**

## Annexure C: Solfruit Arrival Quality Report ( [REDACTED] )



### FRUIT CONDITION REPORT – RECEIVED BY SOLFRUIT INTERNATIONAL BY

#### CONSIGNMENT INFORMATION

<b>Date of arrive:</b>	07-07-2011	<b>Reference Solfruit:</b>	PTN-10-002709
<b>Supplier:</b>	Firm	<b>Vessel:</b>	MAERSK MADRID
<b>Container:</b>	PONU 292652-6	<b>Ryan Recorder:</b>	16164687
<b>Product:</b>	Mangoes Pakistan	<b>Variety:</b>	Sindhri
<b>Brand(s):</b>	Various	<b>Category</b>	Cat I
<b>Amount of pallets:</b>	12 pallets	<b>Amount of cartons</b>	About 1728 boxes
<b>Amount of inspected pallets:</b>	12 pallets	<b>Amount of inspected cartons</b>	85 boxes

#### TEMPERATURE & PACKING INFORMATION

<b>Pulp Temperature</b>	14,3 to 19,2 degrees Celsius. The temperature for mangoes is too high.	<b>Packaging</b>	Open top cartons
<b>Ryan Temperature</b>	15 degrees Celsius	<b>Palletizing</b>	Bad (all the pallets was slanting, bottem layers damaged, because it was too many space between the pallet and the doors. We don't found any label on the boxes with the sizes. The boxes in the middle of the pallets, are without any label with variety – sizes- produce of ..... It's important.
<b>Transport claim:</b>		<b>Gross Weight per carton</b>	4 kg
<b>Size:</b>	6er – 7er – 8er – 9er - 10er	<b>Tarra</b>	360 gram
<b>Traceability Code:</b>	15204611 / 15205611 15202611 / 15203611 15201611	<b>Nett Weight per carton</b>	Average is 3,50kg underweight
<b>Farm:</b>	Murtaza Agriculture Farms		

#### PRODUCT OBSERVATION

<b>Texture consistency</b>	Sensitive to soft      Average is soft
<b>Ripeness &amp; Maturity</b>	Ripe very ripe (pressure lbs= 0 to 4 lbs)
<b>Brix Readings</b>	16,1% - 17,1% - 19,2% - 18,3% - 14,3%
<b>Eating Quality</b>	Good (ready to eat)
<b>External Colour</b>	Greenish yellow undertone to yellow
<b>Internal Colour</b>	Yellow
<b>Internal Defects</b>	Not found during inspection
<b>External Defects</b>	<ul style="list-style-type: none"> <li>• Resin skin damage 10% to 25% (dangerous for more % stem end rot)</li> <li>• Mould on the stem end slight 5%</li> <li>• Scab 8%</li> <li>• Bruising slight 10%      heavy 5%</li> </ul>

- Dry sensitive skin 3% to 5%

**Decay** Yes, 1% to 2,5% Stem –end rot

#### CONCLUSIONS

**Quality Score (from 1-5)** 3 / 4 (because the ripeness – skin defects and decay)

**Necessary Actions** The consignment has to be claim by the supplier for decay – skin defects and ripeness.  
Different pallets has mould and all the pallets bottom layers are damage.  
All the pallets has to be repack and marketed on rapid way because the ripeness.

Pictures included.

1= Excellent

2= Good

3= Regular (part of the consignment is showing problems, quality report has to be considered as a (partial) claim)

4= Poor (the entire consignment is showing serious problems, quality report has to be considered as a claim)

5= Total Loss (the consignment has to be destroyed, quality report has to be considered as a claim)

**Solfruit International B.V.**

**Handelsweg 120**

**2988 DC Ridderkerk**

**The Netherlands**

**Quality Control / Deepak Ganesh**

**Tel: 0031(0) 610912081**

**Fax: 0031(0) 180693598**

**Tel: 0031(0) 180693497 Direct**



**USAID Firms Project**  
info@epfirms.com