
Appendix 8.19

**This case study forms part of the overarching
2017–19 ACIAR Mango Agribusiness Research Program**

Project: Enhancing mango fruit quality in
Asian mango chains

Study: Pakistan

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Prepared by: Aman Ullah Malik,
Mahmood UI Hasan
University of Agriculture Faisalabad,
Pakistan



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1 Acknowledgements

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2 Case summary

Pakistan's mango industry ranks second after citrus with respect to area and production. According to a published report, the total cultivated area of mango crops is approximately 170,000 hectares, with production of over 1.3 million tonnes. There are two major mango-producing hubs within Pakistan: Punjab and Sindh provinces which contribute 76.7% and 22.6% of total production respectively, while Baluchistan and Khyber Pakhtunkhwa (KPK) contribute the remaining share. In 2018, Pakistan exported 64,111.5 tonnes of mango with a value of USD36 million mainly to the Middle East, United Arab Emirates (UAE) and the United Kingdom (UK).

This project, entitled 'Enhancing mango fruit quality in Asian mango chains', was funded by the Australian Centre for International Agricultural Research (ACIAR). Its aim is to improve the quality standards (external and internal) and capacity development in the assessment of mango fruit quality along the entire supply chain by developing a common language, and an easy and brief draft of quality criteria in Asian countries, especially in project partner countries (Cambodia, Indonesia, Pakistan, the Philippines and Vietnam). This research study was conducted in collaboration with stakeholders, including growers, processors, traders and exporters. The assessment included subjective and objective parameters that were developed as a common language for assessing fruit quality.

During 2018, there were two types of studies conducted, including assessment of mango quality (as per the draft manual) along supply chains for international as well as national (domestic) markets and a simulation study for mango exports to China which was conducted at the Postharvest Research & Training Centre, Institute of Horticultural Sciences at the University of Agriculture, Faisalabad. Fruit quality assessments were initiated during the first week of July (1 July 2018) as the commercial cultivar Sammar Bahist Chaunsa (SB Chaunsa) came to its maturity. Up until 30 July 2018, nine consignments were examined for quality assessment at various stages under different categories from the commercial mango-producing district, Multan. Conclusively, all assessors agreed on developing a scoring system and suggested the draft be finalised as soon as possible. Growers who assessed mangoes felt greater confidence in developing a draft that would allow them to easily assess fruit quality by considering the market. However, they suggested a reduction in sample size and assessment time. In simulation studies, two commercial cultivars (Sufaid Chaunsa and SB Chaunsa) were assessed for whole and cut parameters and total soluble solids (TSS) (Brix°). In general, the non-significant difference observed for most of the parameters indicated that there was no negative effect of postharvest quarantine hot water treatment (HWT) at 48 °C for 60 minutes on the external and internal quality of mangoes. Moreover, postharvest diseases were significantly reduced in HWT mangoes; the impact was more significant in Sufaid Chaunsa compared to SB Chaunsa. Skin shrivelling in HWT fruit of SB Chaunsa mangoes was within an acceptable range; cv. Sufaid Chaunsa seemed more robust with respect to HWT.

Results of present studies revealed that mango quality can be maintained throughout the supply chain by adopting the following recommendations:

- Maturity assessment of mango fruit in the field should be an important consideration.
- Quality of fruit should be assessed by using standard criteria (draft manual used).

- Quarantine treatment, if appropriately used (temperature, time), can also help to reduce disease incidence in cv. Sufaid Chanusa during mango export to China.

3 Introduction

3.1 Project background

3.1.1 Cultivars

Mango (*Mangifera indica*) holds a prominent place among tropical and subtropical regions around the globe due to its appealing look, pleasing aroma and flavour (Purseglove, 1972). Mango is produced in more than 87 countries while its total production was approximately 46.5 million tonnes (including mangosteens and guava) during 2016 (FAO, 2016). India is the largest mango producer (approximately 19 million tonnes per year). Pakistan is currently the fourth-largest mango producer after India, China and Mexico with an 8.5% share of the world's mango production. In Pakistan, the mango crop ranks second after citrus with respect to area under cultivation and production, as well as export. Total cultivated area under mango crops in Pakistan is 170,299 hectares with a seasonal production of 1,336,473 tonnes (MNFS&R, 2015–2016). There are two major mango-producing hubs within Pakistan: Punjab and Sindh provinces, which contribute 76.7% and 22.6% to total production respectively (MNFS&R, 2010). There are over a dozen commercial mango cultivars; however, Sindhri, Sammar Bahisht Chaunsa (SB Chaunsa) and Sufaid Chaunsa are the most important exportable mango cultivars of Pakistan due to their attractive colour, aroma, flavour and taste (Amin, 2012) (see Figure 1, Figure 2 and Figure 3).



Figure 1. Major commercial and export cultivar – Sindhri

Source: Author's image



Figure 2. Major commercial and export cultivar – Sammar Bahisht Chaunsa (SB Chaunsa)

Source: Author's image



Figure 3. Major commercial and export cultivar – Sufaid Chaunsa

Source: Author's image

Mango harvest season starts in mid-May in the Sindh province and extends to Sep/Oct in Punjab. District-wise and variety-wise harvest windows are given below (see Table 1 and Table 2).

Table 1. District-based mango harvest calendar

District	May	June	July	August	September	October
<i>Sindh</i>						
Mirpur Khas						
Tando Allah Yar						
Matiari						
T.M. Khan						
Hyderabad						
Nawab Shah						
Nowshero Feroze						
<i>Punjab</i>						
Rahim Yar Khan						
Bahawalpur						
Lodhran						
Khanewal						
Multan						
Muzaffar Garh						

Source: ASLP Best Practices Mango Supply Chain Manual

Table 2. Commercial mango cultivars and harvest window in Pakistan

May	June	July	August	September	October
Malda					
Dusehri					
Sindhri					
Langra					
Anwar Ratole					
SB Chaunsa Late Sindhri					
Fajri					
Kala Chaunsa					
Late Ratole 12 Sufaid Chaunsa					
Azeem Chaunsa					

Source: ASLP Best Practices Mango Supply Chain Manual

3.1.2 Market overview

Domestic market

With a population of over 207 million, there is large domestic market in Pakistan and mango is the most popular fruit among the local population. Mango is predominantly used as fresh fruit; however, value-added products like mango pickles, mango drinks and juices are popular and commercially available. Like other fruits and vegetables, mango supply chains are fragmented and involve several intermediaries (i.e. contractors, wholesalers, commission agents, retailers etc.) (see Figure 4). Mango is mostly packed in wooden crates for domestic market. There is a lack of uniform quality standards, although fruit size and absence of blemishes are the major considerations in grading fruits. Top-quality fruit packs are marked with different names, for example ‘Supreme’ and ‘Super’. Mangoes are mostly sold by street hawkers who purchase their daily requirements from local wholesale markets. Specialist fruit and vegetable shops are uncommon but are found in larger cities (Collins et al., 2007). Due to the opening of the international supermarkets (e.g. Metro and Hyperstar), as well as some local chains, there is growing demand for premium-quality mangoes.

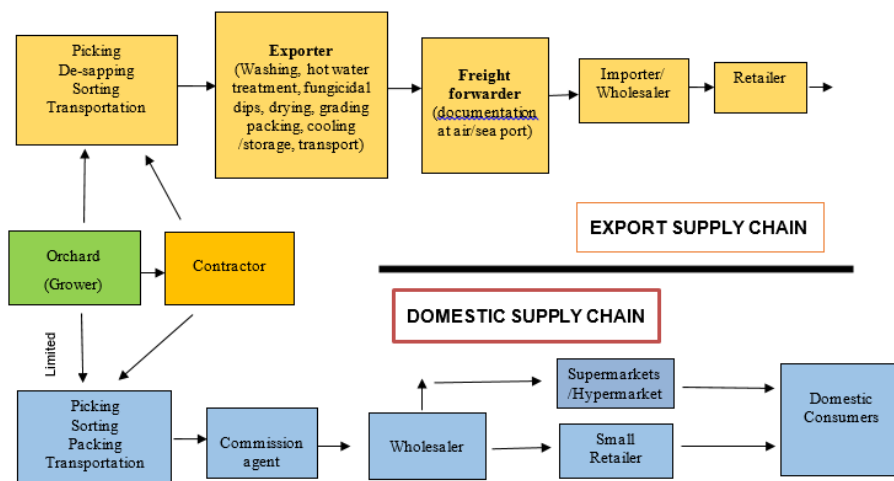


Figure 4. Pakistan mango supply chains

Source: Author's analysis

Export market

Pakistan's mango industry has tremendous potential for export to international markets. Mango export season starts in the Sindh province during last week of May and extends to September in the Punjab province.

Over the last decades, due to several internationally (ASLP, UNIDO, USAID) and nationally funded projects, there has been significant capacity building to promote export. Research and development (R&D) based export protocols were developed under the Pak-Australia Agriculture Sector linkages program—Mango Supply chain/Value Chain projects (Malik et al., 2017). Through a USAID project, on-farm mango processing infrastructure development was supported and 15 pack houses were co-funded in Punjab and Sindh provinces to promote farm direct export. Few grower-entrepreneurs have been successful in mango export marketing.

Pakistani mangoes are mostly exported to UAE, Saudi Arabia, UK, Oman, Germany, Malaysia, Qatar, Canada, Norway and Bahrain (see Table 3), as well as to Afghanistan and Iran (MNFS&R, 2015–2016). Overall export volumes are estimated to exceed 100,000 tonnes annually.

Table 3. Major countries importing Pakistani mango

Country	Quantity (ton)	Value (\$000)
United Arab Emirates	36,195.585	14,840.11
United Kingdom	8,241.485	8,182.729
Oman	7,123.621	2,809.971
Saudi Arabia	4,897.397	3,858.114
Qatar	1,238.804	1,036.071
Canada	1,210.438	754.9143
Norway	682.382	698.8429
Bahrain	678.809	393.6857
Germany	625.515	647.4214
Malaysia	316.964	297.2643
Other countries	2,900.55	2,508.63
Total	64,111.55	36,027.76

Source: MNFS&R, 2015–16

(Note: Export trade with Afghanistan and Iran has not been included.)

Middle East (UAE, Oman, Saudi Arabia, Qatar, Bahrain)

The Middle East is a traditional market for Pakistani mangoes. Export is predominantly by air (estimated >60%); however, significant volumes are also shipped by sea to Dubai and then distributed to other gulf countries. Due to oversupply and quality issues, prices of Pakistani mangoes are low compared to other mango exporting countries. However, due to proximity and large ethnic consumers in the Middle East, this region will remain as a major market for Pakistani mangoes.

UK and European Union market

The UK, along with EU, is the second most important market for Pakistani mangoes. This market is well priced but stringent in terms of fruit quality and traceability. While there are no formal phytosanitary requirements, the consignments are monitored for the presence of live insect pests (e.g. fruit fly) and pesticide residues. Most of the mangoes exported to the UK and EU are consumed by expatriate Pakistanis and other Asian communities living abroad (Collins et al., 2007). However, in the past few years, there has been improved penetration of Pakistani mangoes into UK and EU supermarkets, although the volumes remain limited. Through ASLP support, mango sea freighting to the UK and EU has been established and the Sindh Mango Growers group has been successfully exporting mangoes using air and sea shipments.

China

China is considered a major future export market for Pakistani mangoes due to its large potential for mango consumption, particularly under the new developments of the China Pakistan Economic Corridor (CPEC) and the famous 'One Belt, One Road' program. The two governments (China and Pakistan) have already signed a protocol of phytosanitary requirements for exporting mangoes from the Islamic Republic of Pakistan to the People's Republic of China using HWT (48 °C for 60 minutes). Pakistan has potential opportunities for exporting its late season varieties when Chinese local mango supplies decline. High-end Chinese markets demand large-size, premium-quality mangoes with attractive packaging.

USA

The United States of America (USA) is the largest importer of mango fruit, having a share of about 23.2% with an import value of USD656 million (WRC Report, 2017). Most of the mangoes in the USA are imported from Mexico, Brazil, Peru, Ecuador, Haiti and

Guatemala. Ataulfo (Mexico), Francis (Haiti), Haden (Mexico), Keitt (Mexico), Kent (Mexico, Ecuador and Peru) and Tommy Atkins (Mexico, Guatemala, Brazil, Ecuador and Peru) are the main available cultivars (NMB, USA). Import volumes from other countries are limited.

Since 2010, Pakistan has gained access to USA markets with a phytosanitary protocol of irradiation against fruit fly after arrival in the USA. During the following years, mango export volumes to the USA have remained limited. Recently, the USA government has set up additional irradiation facilities in the states of Mississippi (Gateway America, Gulfport) and Texas (Houston) to help increase Pakistani mango imports. So far, the target markets for Pakistani mangoes in the USA are Houston, Dallas and New York – three cities with large Pakistani communities. For this year (2018), the average Cost & Freight price (C&F) for a 2 kg package (gross weight 2.3 kg at farm gate) was around \$12–13, while retail prices varied between \$22–25. According to exporters, the mango export process to the USA is lengthy and costly. High freight charges (\$2.5/kg) and use of irradiation facilities in the USA are the major obstacles.

Japan

Pakistan obtained access to Japanese markets using phytosanitary protocol of vapour heat treatment (VHT). There are two commercial VHT facilities established by the private sector: Fauji Fresh *n* Freeze and Roomi Foods Pvt Ltd. in Punjab province. While Japan is a highly-priced mango market, meeting quality and food safety standards is very challenging and therefore the export volume still remains around 20,000 tonnes each year.

Other countries

Pakistan has market access agreements with Australia, South Korea, Jordan, Lebanon, Russia and several other countries for the export of mangoes. However, export trade remains either limited or there has been no export to some countries as development efforts to promote Pakistani mangoes is required in those markets.

3.2 Study objectives

This study sought to examine three areas to:

- test the draft quality assessment criteria in order to improve the quality standards (external and internal) and develop a common understanding of quality in the supply chain
- develop capacity in the assessment of exportable quality mangoes during the whole supply chain by developing a common language, and an easy and brief draft of quality criteria in Asian countries, especially in project partner countries (Cambodia, Indonesia, the Philippines and Vietnam)
- conduct simulation studies on commercial cultivars (e.g. Sammar Bahisht Chaunsa (SB Chaunsa) and Sufaid Chaunsa) for potential export to China.

3.3 Study methodology

The quality assessment included both consignments for export and domestic markets. A brief draft manual on quality assessment was evaluated to help all stakeholders of supply chains (especially growers, processors, exporters and importers) to assess the fruit quality by following easy (subjective) criteria of quality assessment at different stages of the supply chain.

Assumptions and limitations

Assessment studies were done on the cultivar Sammar Bahisht Chaunsa during the commercial harvest season in the district of Multan. It is assumed that most of the

representative supply chains have been covered in these assessments. Simulation study for potential export to China also included the cultivar Sufaid Chaunsa which was sourced from Multan. There may be some difference in fruit quality of these cultivars from other regions. Further response of different varieties of mangoes to HWT may also vary.

3.3.1 Study 1: Quality assessment of mangoes during domestic and export supply chains

This study was initiated during the first week of July (1 July 2018) when the commercial cultivar Sammar Bahist Chaunsa comes to its maturity stage and it ran until the last week of July (30 July 2018). During this time, nine consignments were completed for quality assessment at various stages under different categories in the Multan district. Completed consignments with categories and stages are outlined in Table 4.

Table 4. Detail of consignments at different stages and levels of supply chain

C. No.	Stages	Destination
C-1	1. At arrival at VHT plant / before VHT 2. After VHT / packing before dispatch	Japan & Qatar
C-2	1. At harvest in the field 2. At arrival at HWT plant / before HWT 3. After HWT / packing before dispatch	China
C-3	1. At harvest in the field 2. At arrival at HWT plant / before HWT 3. After HWT / packing before dispatch	England
C-4	1. At harvest in the field 2. At arrival at HWT plant / before HWT 3. After HWT / packing before dispatch	England
C-5	1. Local packaging at orchard	Kabir wala, Pakistan
C-6	1. At wholesale fruit & veg. market	Multan, Pakistan
C-7	1. At wholesale fruit & veg. market	Kabir wala, Pakistan
C-8	1. At retail level (roadside stand)	Multan, Pakistan
C-9	1. At retail level (superstore)	Faisalabad, Pakistan

Source: Author's analysis

3.3.2 Study 2: Simulation studies for potential export to China

The simulation experiment on commercial mango cultivars Sammar Bahist Chaunsa and Sufaid Chaunsa for export to China was completed following the research methodology. The proposed study was started on 30 July 2018 on the commercial mango cultivar Sammar Bahist Chaunsa and the first week of August 2018 for Sufaid Chaunsa. Fruit was harvested at the mature green stage from a commercial orchard in Multan and after non-chemical desapping and sorting in the field it was then taken to the Kashan Hot Water Plant. At arrival at the HWT plant, fruit were washed, sorted, and a fungicide was applied, followed by an HWT at 48 °C for 60 minutes (China protocol). After the HWT, fruit were kept at room temperature to cool down. When pulp temperature reached 32 °C, fruit were packed in standard export boxes and transferred to the Postharvest Research & Training Centre at the University of Agriculture, Faisalabad. Fruit boxes were placed at 26±2 °C until ripe.

Treatments

T1 = Washed + no hot water treatment (three boxes or replications)

T2 = Washed + hot water treatment (three boxes or replications)

Parameters of study

Assessment of mango quality parameters was done as per the manual data sheet, where subjective and objective type parameters were recorded, including whole fruit assessment (visual quality, skin defects, skin colour, firmness (score), smell), cut fruit assessment (flesh defects, flesh colour, flesh smell), sensory evaluation and optional parameters (dry matter (%), TSS (Brix^o), TA (%)).

Additionally, disease assessment was completed as per the described scale by Amin et al. (2007).

Table 5. Disease assessment score

Disease incidence	Score
Nil	1
<5%	2
5–10%	3
10–25%	4
>25%	5

Source: MNFS&R, 2015–16

Initial data was collected at day zero, while during the experiment, physical parameters were recorded daily and biochemical parameters were studied at the soft ripe stage.

4 Results and discussion

4.1 Study 1: Quality assessment of mangoes during domestic and export supply chains

Quality assessment of the mangoes was completed for domestic and international consignments. This study was initiated during the first week of July as the commercial cultivar Sammar Bahist Chaunsa comes to its maturity stage. Assessment of nine consignments was completed before the last week of July, while two consignments were assessed after the completion of simulation studies (see Figures 5 to 18).

For the first assessment, the team selected the VHT plant, Roomi Foods Ltd at Kabir Wala (near Multan) as they had started exporting quality mangoes to Japan and Qatar after VHT. Mr Suliman Shah, Deputy Manager of the VHT plant, was the focal person who ensured all mango exporting activities were run correctly. A proforma for the assessment of the mangoes was compiled. After the arrival of harvested mango containers, they assessed all of the suggested parameters in the proforma, including visual quality, skin colour, skin defects, fruit firmness, fruit smell, flesh defects, flesh colour, flesh smell, consumer acceptance (on visual basis) and TSS (using a refractometer) before and after VHT (see Table 5). Mr Shah described his experience undertaking the assessment with the scoring system as very easy, taking approximately one hour to complete. He recommended reducing the time for the assessment and incorporating some parameters pertaining to pre-harvest measures.

Similarly, the second consignment (for China) was assessed at Shujabad, Multan under the umbrella of Zain Enterprises Ltd, at four stages (at harvest in the field, at arrival before HWT, after HWT, at packaging) of the supply chain. Assessment at harvest was undertaken in the orchard of Mr Malik Qaiser Ahmad, at a Moza Muhammad Pur village in Shujabad, Multan. Only skin colour, fruit firmness and skin defects were assessed as routine measures before harvest, while a current assessment was done that included all

the parameters. Mr Malik Qaiser Ahmad's experience was positive in relation to the scoring system and he was satisfied about the manual development.

Mangoes were then assessed after arrival at Zarpak HWT plant (approved for China export) and also after HWT (at packaging). The CEO of the enterprise, Mr Zain, assessed mango quality according to set protocols (i.e. given parameters in the proforma) and remarked that this manual assessment would help make quality assessment simpler as it would allow easy separation of the exportable commodity from defected fruits. His suggestion was to add the parameter of measuring pulp temperature using a temperature probe after HWT.

Two consignments destined for England were assessed at Kashan Enterprises which has an operational HWT plant and developed packing infrastructure. These consignments were also tracked at orchard level during harvesting and growers from different orchards were interviewed (Village 1 – Sadar Pur, Multan, and Village 2 – Nawab Pur, Multan) who remarked that not only maturity was assessed before harvesting, but also fruit size, skin colour and skin defects were considered. This was the first experience for these growers using the developed manual for assessment. They tried to assess all the available parameters (whole and fresh cut). However, the growers suggested making an easy draft for assessment and recommended the scoring system as being the best option to convey information or educate other people. Fruit quality assessment at harvest showed that all physical parameters of both shipments (England) were similar, while there was a significant difference in TSS before HWT (at arrival) and after HWT (at packaging). This was because prior to the HWT process the fruit were still green but physically mature (9–10 Brix°), whereas after HWT, TSS increased (20 Brix°) because after processing, mangoes were kept for one to two days for ripening before being packed.

Mango cultivars (SB Chaunsa and Sufaid Chaunsa) were also assessed for domestic markets from different stages in the supply chain including packaging at the farm level, wholesale fruit and vegetable markets, and retail shops (see Table 6). For the fifth consignment, Mr Muhammad Asif, a grower from the village of Moza Muhammad Wala, Kabir Wala, was interviewed at the packing site. At farm-level packing, growers are used to considering the physical appearance (i.e. skin colour, skin defects, fruit firmness) and they just pack the crates for local and distant national markets. The fruit was assessed by considering scores for whole and cut fruit analysis. Mr Asif asked for a simple draft of quality assessment and suggested minimising the number of fruits per tray (4–5 fruits/tray). Remaining consignments were from wholesale fruit and vegetable markets and retail shops (roadside stands and superstores such as Metro Cash and Carry). On average, shopkeepers considered only the physical appearance (i.e. skin colour and skin defects) and were more responsive toward those given parameters in the questionnaire/data sheet. Shopkeepers suggested an increased focus on an objective-type assessment and also greater emphasis on the scoring system.

Table 5. Quality assessment of export consignments; fruit assessed at different stages of supply chain.

		Visual quality	Skin defects	Skin colour	Firmness	Smell	Flesh defects	Flesh colour	Flesh smell	TSS (Brix°)
C-1	Before VHT	4.33	4.33	1	1	3	4.9	3.04	2.09	8.84
	After VHT <i>Packaging</i>	3.85	3.8	3.09	4.8	4	3.9	3.71	4	*17.04
C-2	At harvest	4.80	4.80	1	1	3	4.85	2.6	3.14	8.06
	Before HWT <i>At arrival</i>	4.95	4.90	1	1	3	4.95	2.90	3.95	8.52
	After HWT <i>Packaging</i>	4.90	4.90	1	1	3	4.04	3.80	3.23	9.02
C-3	At harvest	4.42	4.42	1.04	1	2.0	4.95	2.47	4.04	9.69
	Before HWT <i>At arrival</i>	4.42	4.42	1.04	1	2	4.90	2.33	4.09	10.58
	After HWT <i>Packaging</i>	4.38	4.38	2.95	2.47	3	4.6	2.90	3.47	*20.7
C-4	At harvest	4.42	4.47	1	1	2	5	2.38	4.33	8.26
	Before HWT <i>At arrival</i>	4.28	4.28	1	1	2	4.95	2.19	4.04	9.7
	After HWT <i>Packaging</i>	4.28	4.28	3.33	3	3.23	4.85	2.95	4.09	*20.80

Source: Author's analysis

Notes: Physical (whole and cut) fruit parameters done following scoring available in draft manual.

* Difference between TSS (Brix) before HWT and after HWT (at packing) because process of mango was held for one to two days for ripening using ethylene sachets before packing

C-1: Consignment for Japan and Qatar, C-2: Consignment for China, C-3: Consignment for England, C-4: Consignment for England

Table 6. Quality assessment of domestic consignments at different stages of supply chain.

	Visual quality	Skin defects	Colour	Firmness	Smell	Flesh defects	Flesh colour	Flesh smell	TSS (Brix°)
C-5	4.28	4.33	1	1	3	5	1.85	3.09	11.03
C-6	3.38	3.38	4.85	3.85	4.95	4.90	3.61	5	24.34
C-7	3	3.14	4.76	4.19	4.90	4.80	3.61	5	24.44
C-8	3.04	3.04	4.85	4	5	4.85	3.71	5	24.29
C-9	3.94	3.94	4.94	3.77	4	3.61	3.88	4.05	25.2
C-10	3.88	3.52	5	4	4.55	4.55	3.61	3.88	25.53

Source: Author's analysis

Notes: C-5: Local packaging at orchard (Kabir wala), C-6: At wholesale fruit and veg. market (Multan), C-7: At wholesale fruit & veg. market (Kabir wala), C-8: At retail level (Roadside stand) (Multan), C-9: At retail level (Superstores, Metro Cash and Carry) (Faisalabad), C-10: At wholesale fruit and veg. market (Faisalabad)



Figure 5. Arrival at VHT plant, Japan (Consignment 1)

Source: Author's images

Notes: a. arrival at VHT plant

b. fruit nicely packed in the field with paper lining

c. assessment of whole fruit before VHT

d. assessment of cut fruit before VHT

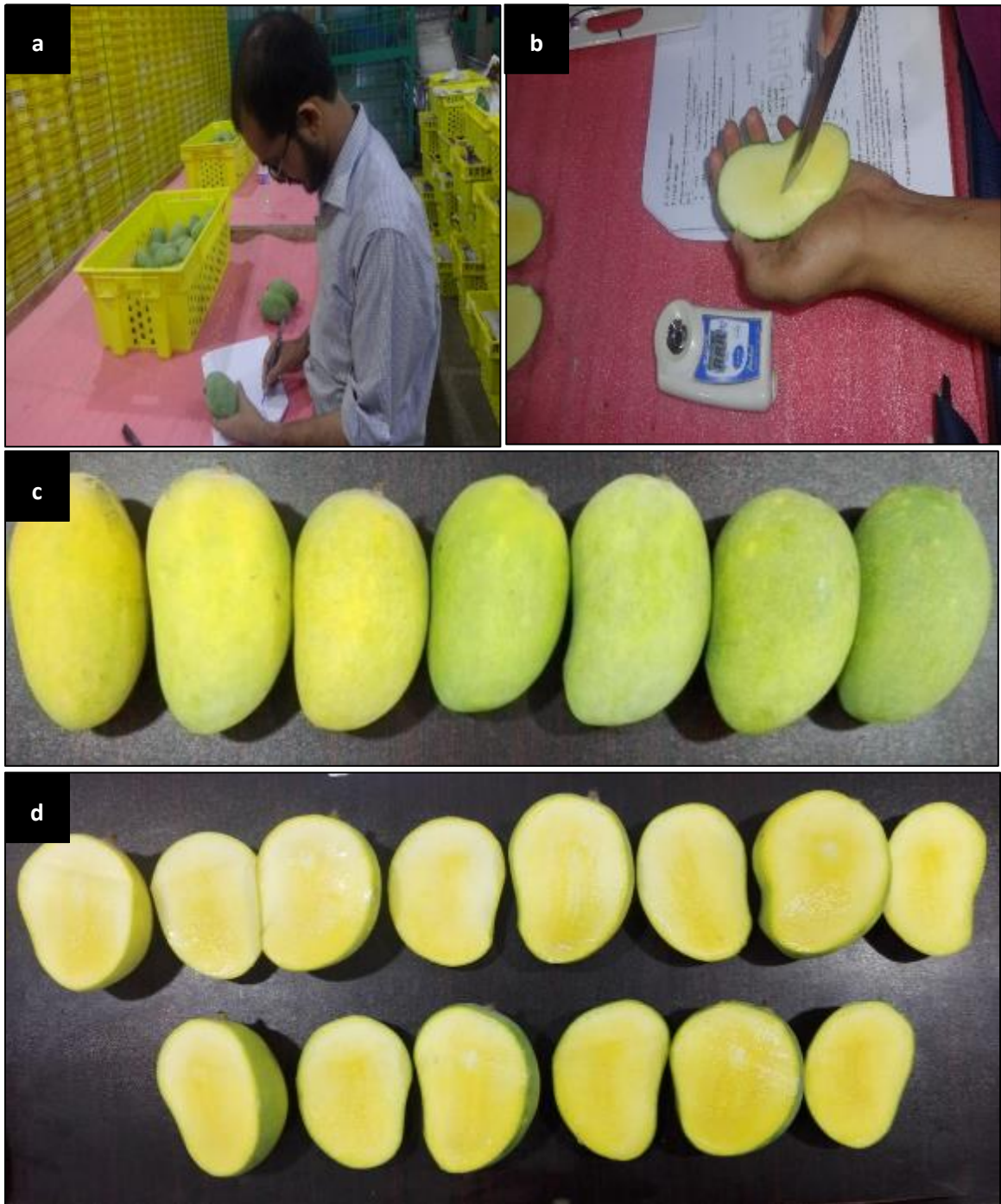


Figure 6. Physical assessment by assessor, Deputy Manager, VHT plant

Source: Author's images

Notes: a., b. assessment including Brix evaluation

c. assessment of whole after VHT

d. assessment of cut fruit after VHT



Figure 7. Mango harvesting in the field for China shipment (Consignment 2)

Source: Author's images

- Notes:
- a. mango harvesting
 - b. placement of fruit on stands for desapping
 - c. assessment of whole fruit at orchard
 - d. assessment of cut fruit at orchard



Figure 8. Consignment arrival at HWT plant in Multan, Shujahabad

Source: Author's images

*Notes: a., b. fruit nicely packed in the field with paper lining
c. assessment of whole fruit before HWT
d. assessment of cut fruit before HWT*



Figure 9. Quality assessment by assessor and exporter at HWT plant

Source: Author's images

Notes: a., b. Brix evaluation using refractometer
c. assessment of whole fruit after HWT
d. assessment of cut fruit after HWT



Figure 10. Harvesting in field for England (Consignment 3)

Source: Author's images

Notes: a. harvesting of fruit

b. transfer of fruit

c. placement of fruit on desapping stands

d. assessment of whole fruit by assessor at orchard

e., f. assessment of cut fruit by assessor at orchard



Figure 11. Harvested fruit arrival at HWT plant

Source: *Author's images*

Notes: *a. arrival at plant*

b. quarantine officer assessment

c. assessment of whole fruit before HWT

d. assessment of cut fruit before HWT

e. assessment of whole fruit after HWT (at packing time)

f. assessment of cut fruit after HWT (at packing time)

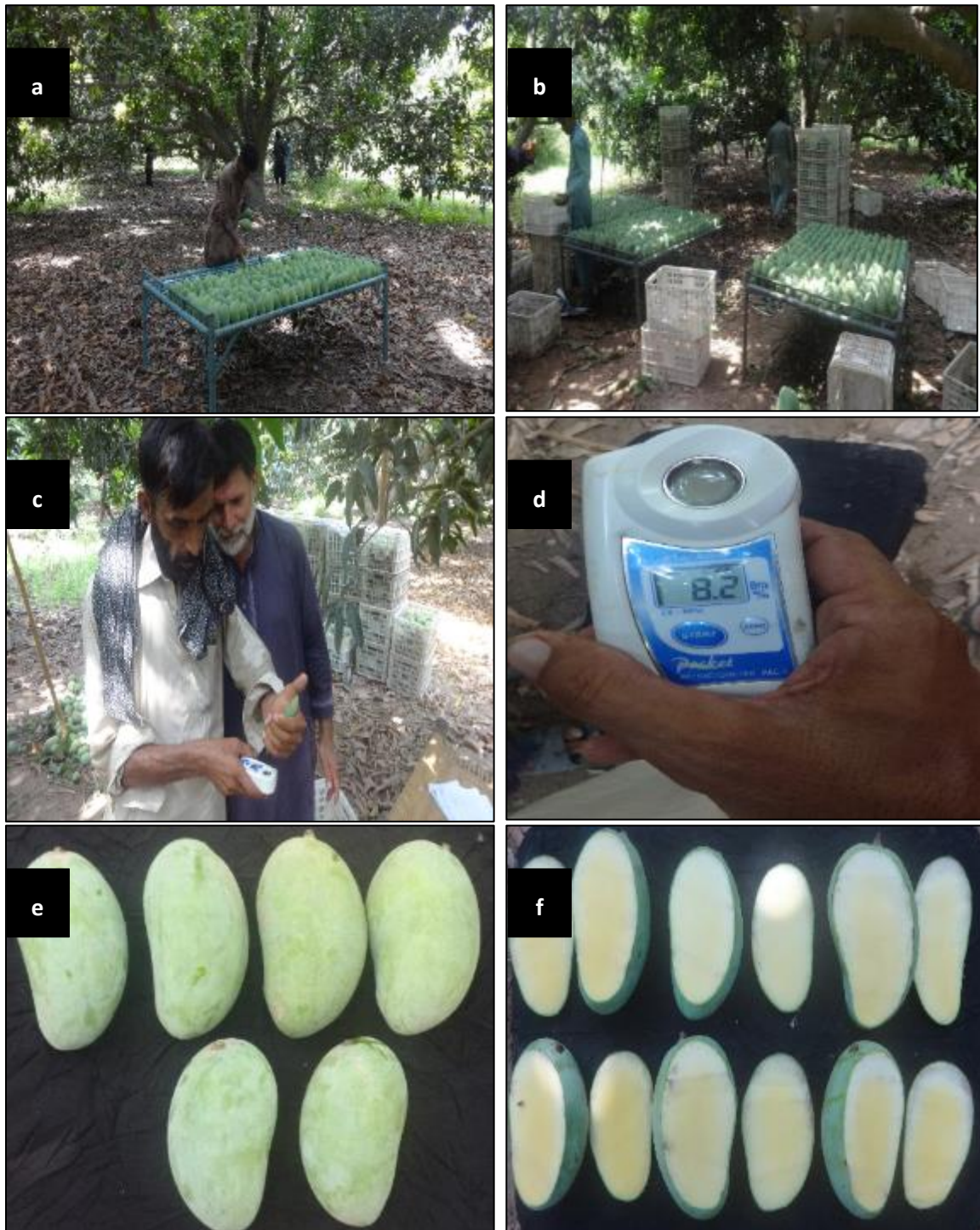


Figure 12. Fruits after harvesting, for England (Consignment 4)

Source: Author's images

*Notes: a., b. mangoes placed on desapping stands
 c., d. Brix evaluation by orchard supervisor using refractometer
 e. assessment for whole fruit
 f. assessment for cut fruit*



Figure 13. Harvested fruit arrival at HWT plant

Source: Author's images

Notes: a., b. arrival at HWT plant

c. assessment (exporter; partner HWT plant) of whole fruit before HWT

d. assessment (exporter; partner HWT plant) of cut fruit before HWT

e. assessment (exporter; partner HWT plant) of whole fruit after HWT (at packing time)

f. assessment (exporter; partner HWT plant) of cut fruit after HWT (at packing time)



Figure 14. Packing for local market at Kabir Wala, Punjab (Consignment 5)

Source: Author's images

Notes: a., c. assessment by packer of whole fruit
 b.. d. assessment by packer of cut fruit
 e. packing in crates
 f. uploading in truck for local market



Figure 15. Mangoes in main fruit and veg. market, Multan (Consignment 6)

Source: Author's images

- Notes:
- a. unloading crates in main market
 - b. mango stand
 - c. interviewing wholesaler
 - d. crate opened for quality assessment
 - e. assessment of whole fruit
 - f. assessment of cut fruit



Figure 16. SB Chaunsa mangoes in Kabir Wala fruit and veg. market (Consignment 7)

Source: Author's images

- Notes:*
- a. SB Chaunsa mangoes in market*
 - b. interviewing wholesaler*
 - c. opening of purchased crate*
 - d. assessment of whole fruit*
 - e. assessment of cut fruit*



Figure 17. SB Chaunsa mango purchased from roadside stand, Multan (Consignment 8)

Source: Author's images

Notes: a., b. mango stand

c. assessment of whole fruit

d. assessment of cut fruit

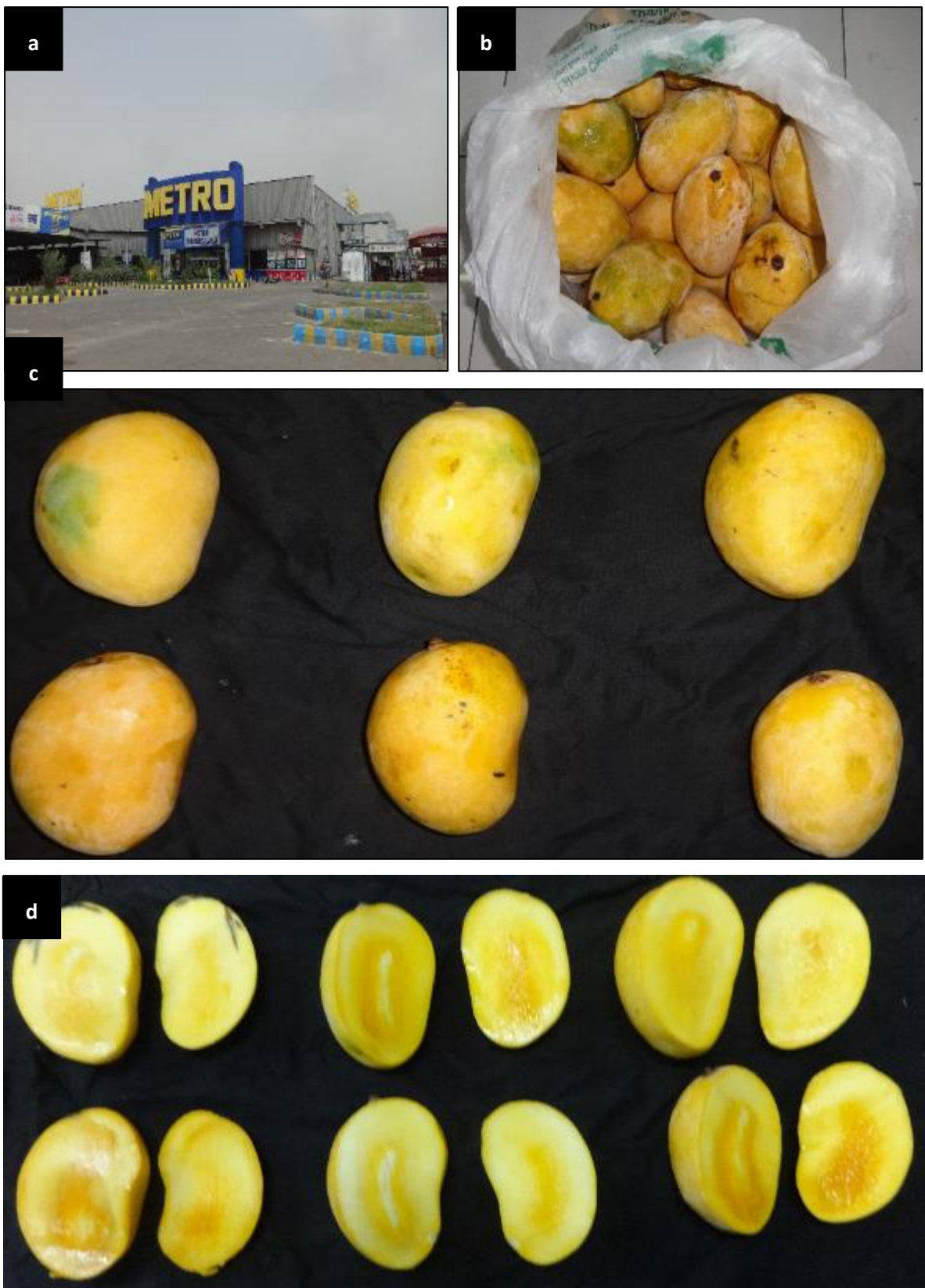


Figure 18. Assessment of mango from Metro retail superstore, Faisalabad (Consignment 9)

Source: Author's images

- Notes:*
- a. Metro retail superstore*
 - b. purchased fruit*
 - c. assessment of whole fruit*
 - d. assessment of whole fruit*

4.2 Study 2: Simulation studies for potential export to China

The simulation study was aimed at evaluating the effect of HWT on mango cultivars (SB Chaunsa, Sufaid Chaunsa) for potential export to China. After standard processing and HWT (48 °C for 60 min), fruit boxes were placed at 26±2 °C until they reached a ripe stage. After ripening, whole and cut fruit were subjected to physical and biochemical analysis. In the SB Chaunsa cultivar, there was no significant difference observed in HWT and non-HWT fruits. In visual quality, no significant difference was observed while mangoes in T₂ (HWT) scored more in visual quality (4.6) compared to T₁ (non-HWT) (see Figure 19). Similarly, skin colour, firmness, fruit smell, flesh colour, flesh smell and flesh defects showed no significant results. However, fruit shrivelling was more apparent in HWT compared to non-HWT mangoes, but the fruit was still acceptable to consumers. Disease incidence was significantly reduced in HWT mangoes (1.13), while non-treated mangoes had a higher disease assessment score (1.83). TSS was the most important parameter of quality assessment for the export market where there was no significant difference observed between the treated and non-treated fruits.

The second cultivar (Sufaid Chaunsa) was subjected to a similar type of analysis after ripening. In visual quality, fruits were more attractive and the score was higher after HWT compared to the control group. In whole and cut fruit analysis, skin colour, fruit smell, fruit firmness, flesh colour and flesh smell had no significant differences between the T₁ (non-HWT) and T₂ (HWT) treatments. Skin defects correlated to disease incidence on the fruit surface and there were significant differences observed in HWT mangoes compared to the control group. Regarding skin defects, non-treated mangoes scored a rating of 3.2 (moderate) compared to a rating of 4.3 in the treated (slightly towards no defect) fruits. Similarly, symptoms of postharvest disease 'stem end rot' was apparently observed in non-treated mangoes and scored 3.05 (5–10%), while disease incidence was reduced with a score of 1 (nil) in treated (HWT) fruit boxes. However, there was no significant difference in TSS between the treated and non-treated mangoes (see Figure 20).

A similar trend was observed in both cultivars, as the heat treatment in the form of hot water at 48 °C for 60 min (China protocol) did not have a significant negative effect on the quality of the fruit. Most of the parameters showed non-significant results which conveyed to exporters and importers that quality (external and internal) is not affected by HWT; a technique which is required as a quarantine measure in various countries.

Non-significant results among HWT and non-HWT mangoes showed a positive correlation with the quality of mangoes. The present study displayed similar results for whole or cut fruit parameters showing that quality was not affected even after ripening in a controlled condition. Postharvest disease incidence was reduced in cultivars of Sufaid Chaunsa followed by SB Chaunsa, using HWT compared to the control group. SB Chaunsa showed higher skin shrivelling in HWT mangoes but remained within an acceptable range. Both varieties (SB Chaunsa and Sufaid Chaunsa) can be exported to China and other Asian markets.

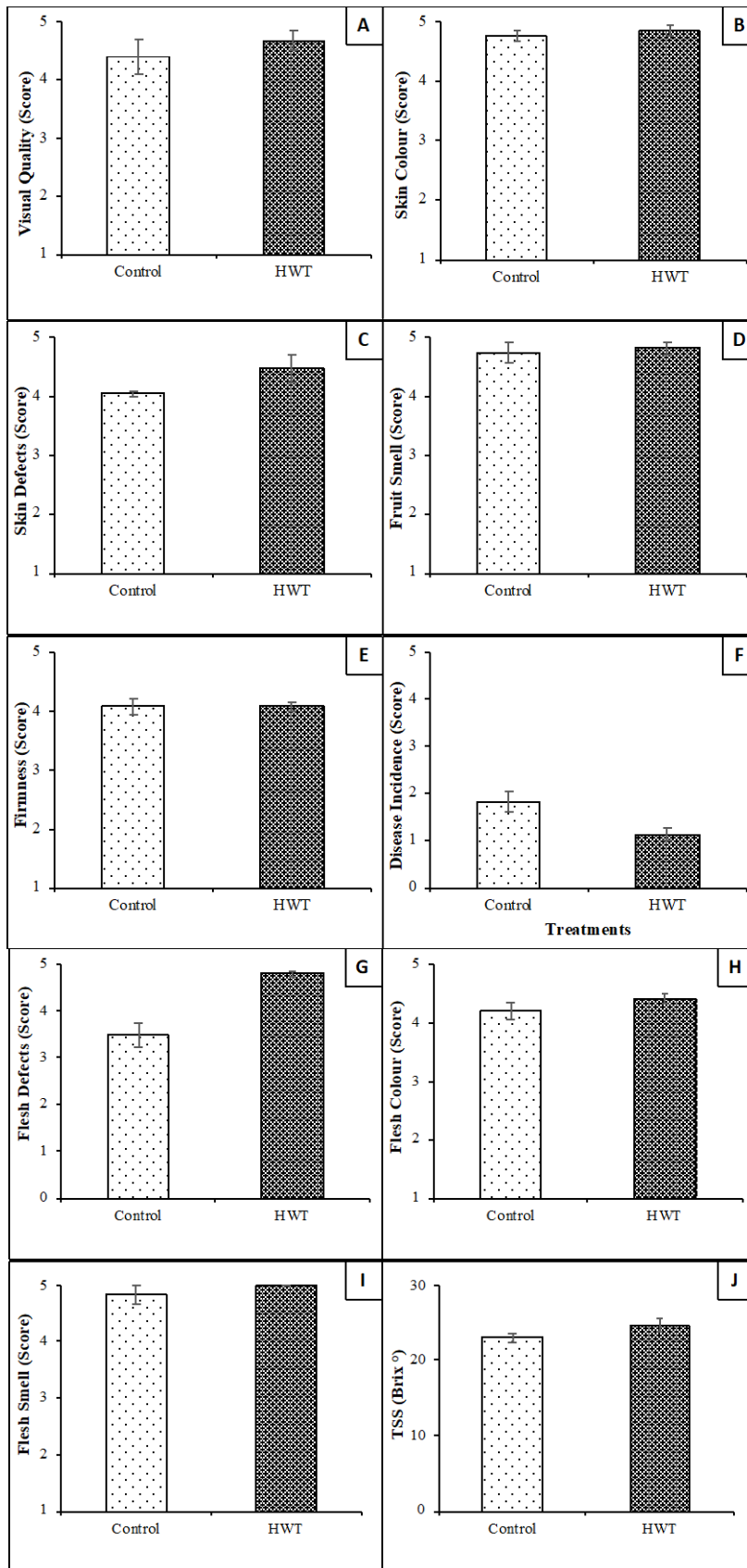


Figure 19. Treatment analysis, SB Chaunsa mango variety

Source: Author's analysis

Notes: (T1 = non-HWT, T2 = HWT) in whole/cut fruit analysis; visual quality (A), skin colour (B), skin defects (C), flesh smell (D), firmness (E), disease incidence (F), flesh defects (G), flesh colour (H), flesh smell (I) and TSS (J) for 'Sammar Bahisht Chaunsa. Vertical bars represent SE_{\pm} of the means (n=3).

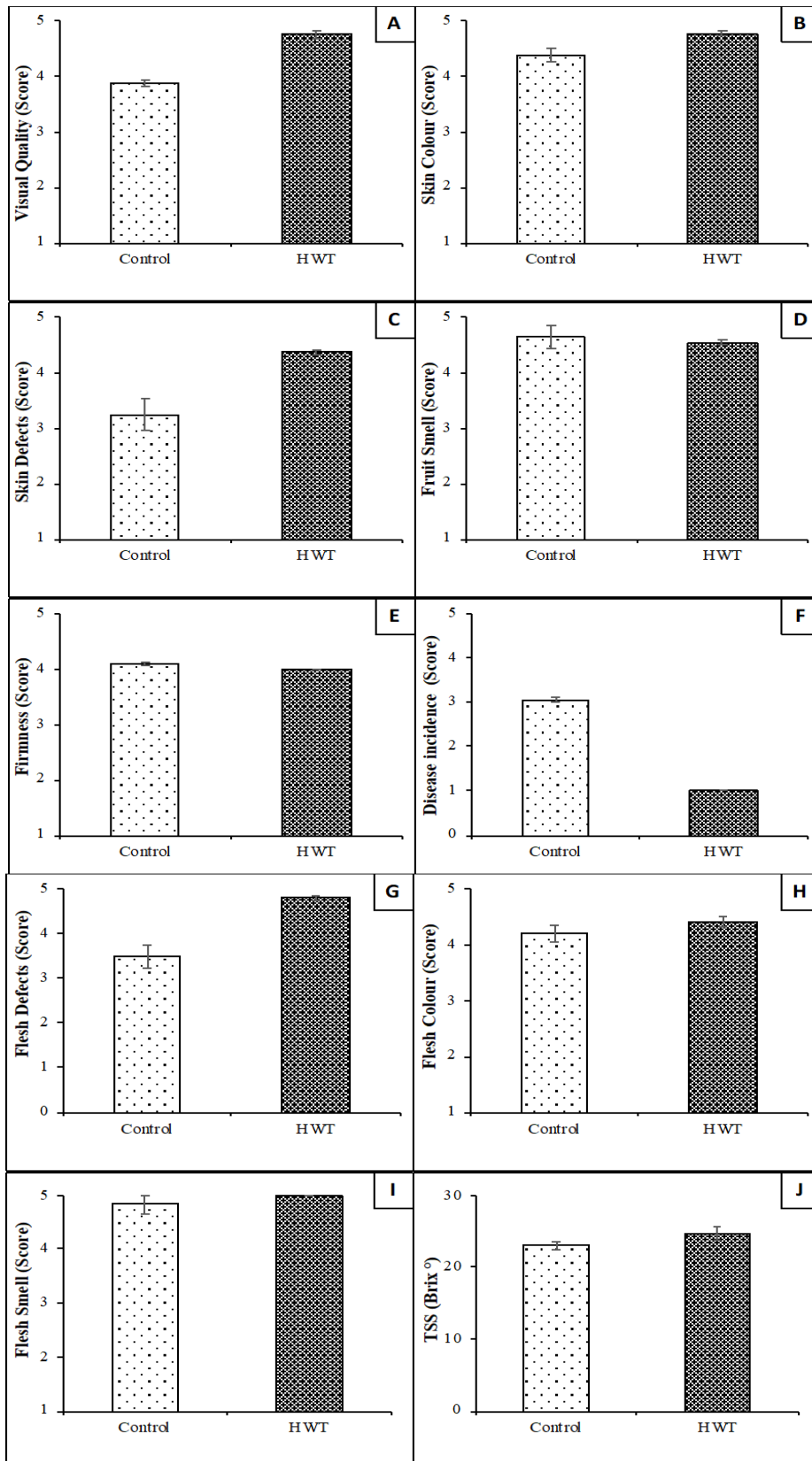


Figure 20. Treatment analysis, Sufaid Chaunsa mango variety

Source: Author's analysis

Notes: (T1 = non-HWT, T2 = HWT) in whole/cut fruit analysis; visual quality (A), skin colour (B), skin defects (C), flesh smell (D), firmness (E), disease incidence (F), flesh defects (G), flesh colour (H), flesh smell (I) and TSS (J) for Sufaid Chaunsa. Vertical bars represent SE_{\pm} of the means (n=3).

5 Conclusion and recommendations

5.1 Conclusion

In conclusion, the assessment of fruit quality in the Pakistani mango trade will benefit stakeholders (including growers, exporters and importers) at national and international levels. The draft of a common language should help to address the suggestions given by processors and growers, including further simplification of the criteria and reduction of sample sizes to reduce assessment times. Where appropriate, pulp temperature recording should also be included.

The simulation study revealed that the two commercial mango cultivars can be exported to China and other Asian markets by following the standard protocol of HWT. In general, HWT had no significant negative effect on the quality of mangoes, whereas it did reduce disease incidence in treated fruits. Sufaid Chaunsa seemed to be more robust in terms of HWT effects as it did not show any sign of skin shrivelling.

5.2 Recommendations

After completing road testing exercises using the draft manual, the following suggestions for the improvement of mango quality in supply chains are:

- Maturity assessment of mango fruit in the field should be an important consideration.
- Quality of fruit should be assessed using standard criteria (draft used) throughout supply chain.
- Records of pulp temperature (where appropriate) should be part of the assessment.
- Minimise the sample size (4–5 fruits/tray) to help reduce assessment times.
- Quarantine treatment if appropriately used (using the correct temperature and time) can help also to reduce disease incidence, especially in cv. Sufaid Chaunsa.

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