Postharvest Handling of Mango

Technical Report

By

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Contents

Abstract ............................................................................................................................................. 4
Introduction ........................................................................................................................................ 6
Background on Mango Production and Handling in Egypt ............................................................... 10
Yield .................................................................................................................................................. 15
Quality .............................................................................................................................................. 19
  Soluble Solids Content in Some Egyptian Cultivars .................................................................... 20
Maturity and Harvesting Indices ....................................................................................................... 22
  Practice in Egypt .............................................................................................................................. 23
  Recommendations Regarding Maturity and Harvesting Indices .................................................. 23
Harvesting ......................................................................................................................................... 34
  Practice in Egypt .............................................................................................................................. 34
  Recommendations on Harvesting .................................................................................................. 39
Latex .................................................................................................................................................. 42
  Handling in the Field ....................................................................................................................... 43
Diseases ........................................................................................................................................... 46
  Disease Control Treatments .......................................................................................................... 47
Insects ............................................................................................................................................... 50
Heat Treatments ............................................................................................................................... 52
  Insect Disinfestation Treatments .................................................................................................... 52
  Hot Air ........................................................................................................................................... 53
  Hot Water ..................................................................................................................................... 53
Irradiation ......................................................................................................................................... 56
Sorting and Grading ........................................................................................................................... 57
Waxing ............................................................................................................................................. 59
Packaging ......................................................................................................................................... 60
  Practice in Egypt ............................................................................................................................. 60
  Recommendations on Packaging .................................................................................................. 62
Types of Packages Commonly Used for Mango in the World and their Characteristics ................. 65
  Package Liners ............................................................................................................................... 68
  ISO Standards ................................................................................................................................. 69
Precooling ......................................................................................................................................... 70
Ripening ........................................................................................................................................... 71
  Practice in Egypt ............................................................................................................................ 71
Abstract

Egypt has excellent potential for the development of a very prosperous mango industry. There is a long tradition of mango cultivation, and the fruit is extremely popular in the local market, both fresh and processed. Egypt produces a significant amount of this fruit, and there are indications for a very significant increase in yield. This is very significant considering that there is practically (except for a very small industry in Israel and Sudan) no competition at all from neighboring countries. Egypt is close to excellent markets for this fruit, especially the European markets. The Arab markets are another important potential venue for Egyptian mango.

However, there are several complex problems facing this industry and severely limiting its development. These can be divided into three major categories: preharvest, postharvest, and logistic.

An excellent and detailed explanation of preharvest and logistic problems, and some postharvest problems is given in the Sub-sector Study developed by the collaborative effort of all sectors and published by ATUT/RONCO in May 1997. These problems must be solved to improve the industry.

The objectives of this report are:

1. Evaluate the postharvest handling of mango in Egypt.
2. Identify the major problems facing the postharvest handling of the fruit.
3. Suggest solutions for these problems.
4. Suggest a text for “Egyptian Standards for Mango”
5. Suggest a working plan for a “Quality Control System for Mango” during production and handling
6. Establish “General Recommendations for the Postharvest Handling of Egyptian Mango”

Strong efforts are being made by all the different sectors in Egypt to improve the industry. Therefore, the time is right to carry out a consistent and long-term plan that takes into account all aspects of mango production and handling. This plan should include research, extension, and promotion.

It is hoped that this report can contribute to these efforts toward improving the production and handling of such a very important fruit in Egypt.
Above all, it is hoped that this report can be translated into Arabic, so that its possible benefits can get to as many users as possible. The author is willing to re-write the text in Arabic with some logistic help (especially writing and editing) from Egypt.
Introduction

This report is the result of observations made during two visits to Egypt: March 26 to April 19, and July 24 to August 14, 1998. The two assignments aimed to evaluate the postharvest handling of mango in the country (see the two trip reports).

The first trip took place before the mango season to:

1. Look at mango orchards.
2. Observe packinghouses and packaging systems and materials used for other fruits and vegetables, and the possibility of using them for mango handling.
3. Observe handling of the different fruits after packaging and during marketing.
4. Investigate Egyptian and other quality standards for mango.

The scope of this trip was set by RONCO was:

1. To collect and review mango export standards from Mexico, USA, South Africa, Israel and some other foreign import/export countries.
2. To propose grades and standards for the export of cultivars such as Tommy Atkins, Kent, Keitt and other select international and recommended local cultivars.
3. To obtain information on packaging material and type of boxes currently in use by the mango fruit exporting countries.
4. To recommend adequate packing materials and boxes to be used for fresh fruit mango exports from Egypt.

The second trip was scheduled for the early days of the mango harvesting season. Harvesting during the trip was carried out in most of the mango regions, although some were earlier than others. For example, El-Ismailia and El-Fayoum were among the earliest regions visited (we did not visited the southern part of the country, which is the earliest region). Among the latest growing regions visited were El-Giza and Edco and Rasheed in El-Behera Governorate.

The scope of work for the second was set by RONCO is described below:

Mango fruit production is mainly for local markets. Given the increasing interest of developing a mango export system, efforts have been made towards introduction of market-demanded cvs. It is thus necessary to evaluate the actual conditions of mango
harvesting and postharvest handling and recommend technological changes to improve the system. The consultant will:

1. Visit and evaluate mango harvest and postharvest handling operations in different areas of Egypt.
2. Detect, analyze and recommend technological suited postharvest practices.
3. Train Egyptian personnel to carry out the proper mango handling procedures.
4. Analyze and evaluate mango packaging materials and systems and recommend the most suitable box type.
5. Present a seminar, final report and recommendations.

During the two trips, several things were accomplished, including:

1. Visits to more than 20 mango farms in almost all mango growing regions, mostly with harvesting activities (second visit). Trees in the orchards visited ranged between 4 months and more than 40 years old.
2. Observation and evaluation of the quality of produced mango fruit, harvesting, and postharvest handling.
3. Evaluation of packages used.
4. Visits to the major wholesale and retail markets in Cairo, and observation of marketing systems and available infrastructure.
5. Visits to several packinghouses (especially during the first visit), which although used for other fruits, can be also used for mango. On-site suggestions were made at one facility (El-Hoda) on modifications to accommodate mango.
6. Visited fruit processing plants, where mango juice is made.
7. Visits to universities and research institutes where research on mango production and postharvest handling is carried out. Universities visited include Suez Canal University, University of Alexandria, and Ain Shams University. Research institutes visited include the Agriculture Research Institute and the National Research Institute. Seminars were given at Ain Shams and Suez Canal universities on mango handling and research.
8. Meetings took place with all sectors of mango production and handling including growers, local marketing agents, middlemen, wholesalers, exporters, researchers, government authorities and technicians, etc.
9. Worked with and trained more than 30 producers, exporters, researchers from universities and research institutes, personnel from ATUT, RONCO, HEIA, and the Ministry of Agriculture and Land Reclamation.

10. Export markets were studied for quality requirement, prices, standards, etc.

11. Different mango quality standards, including international standards, Egyptian standards (for local market and for export), EC standards, and Mexican standards, were investigated in relation to the improvement of Egyptian standards.

12. Some preliminary field research was done to help in the development of maturity indices for some of the important cultivars.

13. Seminars were given during both trips at ATUT/RONCO, Ain Shams University, and Suez Canal University on mango handling and research.

14. Participation in the mango postharvest workshop organized by ATUT/RONCO.
Fig. 1 Map of Egypt showing the mango regions visited.
Background on Mango Production and Handling in Egypt

Mango is a very popular and traditional fruit in Egypt. It is grown commercially in 23 of the 27 governorates. Some of the mango orchards are about 150 years old. Cultivated area, yield, and total production have increased steadily in the last few years (Tables 1 and 2). There are about 68,000 feddans (acres) producing annually about 200,000 tons of fruit.

The area of cultivation increased from 37,000 fed in 1987 to 57,483 fed in 1995, 64,000 fed in 1996, and is expected to reach 148,000 fed in 2010. Production increased from 110,000 tons in 1987 to 216,000 tons in 1996, and is expected to reach 837,000 tons in 2010. About 86% of the mango production is concentrated in five governorates (Sharkia, Ismailia, Giza, El-Fayoum, and Nubaria). Mango production is concentrated between Ismailia and the eastern part of Sharkia, both areas producing about 60% of the total amount of mango produced in the country annually. Production area in El-Sharkia is 31% of the total in the country, El-Ismailia is 23%, and Giza is 17%.
Yield is estimated to be about 4.8 tons/fed (personal communication, Mr. Ibrahim Sheta, General Director of horticulture at the Ministry of Agriculture and Land Reclamation), and varies significantly in the different governates, as indicated in Table 2.

Table 1 Planted area (feddans), yield (tons/feddan), total production (tons) of mango in Egypt in 1987, 1995 and 1996.

<table>
<thead>
<tr>
<th>Year</th>
<th>Planted area</th>
<th>Yield</th>
<th>Total production</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987</td>
<td>37,000</td>
<td></td>
<td>110,000</td>
</tr>
<tr>
<td>1995</td>
<td>57,483</td>
<td>4.09</td>
<td>196,87</td>
</tr>
<tr>
<td>1996</td>
<td>68,000</td>
<td>4.8</td>
<td>216,000</td>
</tr>
</tbody>
</table>

Table 2 Total area (feddans), productive area (feddans), yield (tons/feddan), and total production (tons) of mango in the different governorates in 1995.

<table>
<thead>
<tr>
<th>Governorate</th>
<th>Total Area</th>
<th>Productive Area</th>
<th>Yield</th>
<th>Total Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alexandria</td>
<td></td>
<td></td>
<td>1.5</td>
<td>3,238</td>
</tr>
<tr>
<td>Assuit</td>
<td>536</td>
<td>448</td>
<td>4.54</td>
<td>2,034</td>
</tr>
<tr>
<td>Asswan</td>
<td>670</td>
<td>623</td>
<td>3.77</td>
<td>2,348</td>
</tr>
<tr>
<td>Behera</td>
<td>1,084</td>
<td>803</td>
<td>4.03</td>
<td></td>
</tr>
<tr>
<td>Beni Suef</td>
<td>198</td>
<td>178</td>
<td>5.34</td>
<td>952</td>
</tr>
<tr>
<td>Cairo</td>
<td>296</td>
<td>270</td>
<td>2.34</td>
<td>633</td>
</tr>
<tr>
<td>Dakahlia</td>
<td>73</td>
<td>69</td>
<td>3.7</td>
<td>218</td>
</tr>
<tr>
<td>Damietta</td>
<td>20</td>
<td>16</td>
<td>3.11</td>
<td>51</td>
</tr>
<tr>
<td>Fayoum</td>
<td>3,612</td>
<td>3,508</td>
<td>5.60</td>
<td>19,644</td>
</tr>
<tr>
<td>Gharbia</td>
<td>444</td>
<td>409</td>
<td>5.89</td>
<td>2,447</td>
</tr>
<tr>
<td>Giza</td>
<td>6,773</td>
<td>5,738</td>
<td>4.86</td>
<td>27,860</td>
</tr>
<tr>
<td>Ismailia</td>
<td>18,252</td>
<td>16,635</td>
<td>2.46</td>
<td>40,956</td>
</tr>
<tr>
<td>Kufr El-Sheikh</td>
<td>25</td>
<td>25</td>
<td>3.17</td>
<td>218</td>
</tr>
<tr>
<td>Menofia</td>
<td>927</td>
<td>258</td>
<td>4.01</td>
<td>1,037</td>
</tr>
<tr>
<td>Minya</td>
<td>251</td>
<td>246</td>
<td>1.57</td>
<td>386</td>
</tr>
<tr>
<td>New Valley</td>
<td>181</td>
<td>106</td>
<td>2.97</td>
<td>315</td>
</tr>
<tr>
<td>Nobarya</td>
<td>7,915</td>
<td>3,014</td>
<td>5.01</td>
<td>15,101</td>
</tr>
<tr>
<td>Qalubia</td>
<td>1,223</td>
<td>1,164</td>
<td>3.7</td>
<td>4,309</td>
</tr>
<tr>
<td>Quena</td>
<td>797</td>
<td>793</td>
<td>8.05</td>
<td>6,382</td>
</tr>
<tr>
<td>Sharkia</td>
<td>13,675</td>
<td>13,332</td>
<td>4.96</td>
<td>66,171</td>
</tr>
<tr>
<td>Sinai, North</td>
<td>36</td>
<td>27</td>
<td>1.71</td>
<td>45</td>
</tr>
<tr>
<td>Sinai, South</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sohag</td>
<td>288</td>
<td>259</td>
<td>4.53</td>
<td>1,172</td>
</tr>
<tr>
<td>Suez</td>
<td>196</td>
<td>196</td>
<td>7.2</td>
<td>1,411</td>
</tr>
</tbody>
</table>


The increase in the production of mango in the last few years is due to both new cultivations and an improvement in yield.

Several varieties of excellent organoleptic characteristics are produced in the country. There are 19 commercially grown cultivars, and about 150 known to be present in the country. Most of the commercially grown cultivars are not fully colored when mature (usually mature with a green or light yellow color), and therefore they are not well known nor are they preferred in the international markets.
Fig. 3 Some of the commercial mango cultivars produced in Egypt. Notice the variation in characteristics.

Table 3 Some of the commercially produced mango cultivars in Egypt and their characteristics.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfonse</td>
<td>Yellow to orange ground color with orange flesh, relatively firm, medium to small fruit, low fibers, small seed.</td>
</tr>
<tr>
<td>Company</td>
<td>Yellow-green ground color, yellow flesh, firm texture, low fibers, sweet, medium to large fruit, small seed.</td>
</tr>
<tr>
<td>Ewais</td>
<td>Yellow-ground color, low fibers, very sweet, rich intense flavor, small fruit, small seed.</td>
</tr>
<tr>
<td>Hindi Bisennara</td>
<td>Green ground color with orange flesh, very sweet, small fruit.</td>
</tr>
<tr>
<td>Hindi Khassa</td>
<td>Green ground color, medium-sized fruit, seed relatively large, good flavor.</td>
</tr>
<tr>
<td>Mabrouka</td>
<td>Yellowish-red color when ripe with bright red blush, orange flesh, medium to large fruit, low fiber, firm texture, small seed.</td>
</tr>
<tr>
<td>Misk</td>
<td>Orange-yellow ground color with red blush, sweet flavor, small to medium-sized, relatively big seed.</td>
</tr>
<tr>
<td>Pairi</td>
<td>Yellow with red flush, orange flesh, sweet flavor, low fiber, firm texture, small seed.</td>
</tr>
<tr>
<td>White Succary</td>
<td>Pale green ground color with yellow flesh, medium-sized fruit, thin and smooth skin, juicy and sweet flavor, low fibers, medium-sized seed.</td>
</tr>
<tr>
<td>Taymour</td>
<td>Green ground color when mature, very low fibers, medium-sized fruit, small seed, sweet, strong mango flavor, thick juicy flesh.</td>
</tr>
<tr>
<td>Zebda</td>
<td>Dark green ground color, orange flesh, firm, sweet rich flavor, large fruit with relatively small size seed.</td>
</tr>
</tbody>
</table>

The mango harvesting season in Egypt is between late May early June and October. Upper Egypt (Aswan and Qena) is the earliest producing region (May-July), and the predominant cultivars are Taymour, Ewais and Zibda. Middle Egypt (Ismailia, Giza, and Qalubia) is intermediate (July-September), and the predominant cultivars include Mabrouka, Ewais, and Misk. Lower Egypt (Beheira, Nobaria, Gharbia, Sharkia) is
the latest producing region (September-October), and the predominant cultivars are Misk, Mabrouka and Ewais.

Almost all the fruit produced in the country is consumed locally. Local prices are generally high. There are indications that the increased production of mango has decreased the local prices. Local prices per kg reported a drop of 40% from 1993 to 1994 (Harrison et al. 1994). The continued increase in production will certainly keep lowering the prices.

Fig. 4 Mango consumption in the country is very popular.

Most of the produced fruit (about 95%) is consumed fresh, while only about 8,000 to 10,000 tons are processed, mostly as juice.

Export is about 1.2% of total production (about 2,400 tons annually) mainly to the Arab markets (Gulf States and Libya) and a small amount to England.
Due to the strong national market, closeness to important markets in Europe and the Arab world, long tradition of growing mango, a well established industry for processing (mainly for juice), Egypt could benefit very much from the mango industry.

Strong efforts are being made to improve production and postharvest handling. However, many misconceptions and customs related to production techniques, and especially to harvesting and postharvest handling operations are still delaying the improvement of the industry. However, there is an excellent drive and energetic belief in the improvement of the industry.
Yield

Yield, especially for export-quality fruit, is still low and should be increased. Yield is estimated to be 4.8 tons per fed, but there are major discrepancies among different areas and different orchards. Some orchards are reported to yield up to 7 tons per feddan while others are obtaining less than two tons per feddan.

There are strong discrepancies in yield between different years due to alternate bearing. It seems likely that this problem is due mainly to deficient programs of fertilization and irrigation. Fertilization is commonly applied very late to the tree. The mixing of cultivars in the same block, in addition to inter-planting mango with other crops, make the establishment of adequate fertilization and irrigation programs practically impossible.

Fig. 5 Several fruit trees are cultivated in an inter-planting manner with mango trees. The most common are citrus trees.
It is important to keep in mind that for export to be improved a large amount of high and consistent quality fruit should be available.

Several preharvest factors need to be improved including varietal selection, rootstock selection and use, alternate bearing, pruning and control of tree size and vigor, fertilization, irrigation, and disease and pest control.

The cultivation of many varieties in the same orchard will not allow for the accumulation of significant amount of fruit, especially for export. Production should be restricted to very few promising cultivars. That way a significant quantity of fruit of a certain cultivar can be accumulated.

The use of several and mixed varieties in the same orchard, commonly in the same line (and even the use of several varieties on the same tree in some extreme cases) is very inadequate and contributes to major difficulties and increased costs of cultural management and in lowering the yield.

Trees are commonly very high and very vigorous and need to be controlled by intensive pruning.

Inter-planting mango trees with other fruit trees such as citrus, palm trees, olives, guava, etc. is very common. This contributes to many problems such as pest (fruit fly) infestation, shading, difficulties in fertilization and irrigation programming, and a significant decrease in yield.

The problems facing the improvement of yield and quality of mangoes are excellently detailed in several reports published by ATUT/RONCO. They are discussed here in much less detail because they are related to postharvest problems.

There are many factors that can influence yield, maturity and quality of the fruit. The same cultivar can attain different characteristics in different growing conditions. Even in the same region, different environmental conditions at different years can affect maturity and quality of the fruit.

Light is important for photosynthesis and yield, and for the development of the pigments responsible for fruit color. The intensity of light in a specific region will determine the quality of the fruit from the standpoint of color. The differences in light intensity between mango growing regions can produce fruit of different colors. Adequate pruning techniques are important to insure a better exposure of the tree to light.
Temperature is a very important factor that influences fruit maturity and quality. Temperature can influence, not only the suitability of the growing region for mango cultivation, but also the harvest period, and the quality of the fruit. The minimum temperature (base temperature) at which mango will not develop normally is 17.9°C. Heat units, which are calculated from the sum of the temperature units (degree days) in excess of the base temperature over the growing season, has been calculated in some countries for mango.

The amount of and distribution of rainfall not only determines the suitability of the region for mango growing, but also influences the maturation and quality of the fruit. Mango growing is generally successful when the annual rainfall ranges between 75-350 cm per year, and that there is no waterlogging, and the rain does not fall during flowering, fruit set and fruit development.

Mango trees, especially young trees, need an adequate supply of nutrients for adequate rapid growth, flowering, and fruiting. The timing of fertilizer application is also of great importance. Excessive application of nitrogen can adversely affect the color of mature fruit. The addition of potash to trees with excess nitrogen can improve the color and flavor of the fruit. Potash deficiency is associated with small fruit of poor quality, and high potash levels are associated with an increase in physiological breakdown of the fruit. However, this problem has also been attributed to calcium deficiency. The high potash level can result in a lack of balance between potassium and calcium in the tree and in the fruit. The requirement of mango for phosphorus is usually low, and the deficiency for such elements is usually uncommon. Deficiency of boron and calcium adversely affect the keeping quality of mango fruit. Nutrient imbalance can cause the development of fruit disorders such as internal breakdown and jelly seed.

Mango growing is ideal when at least 4 months of dry weather occurs between flowering and harvest. In this period and in other periods when rainfall is not possible, irrigation is needed. Prolonged moisture stress can result in late flowering and small fruits.

Insects and diseases result in loss of yield and deterioration of quality, and thus adequate control is essential. Preharvest pest control contributes very significantly to increased yield and improved quality, but may adversely influence quality from the standpoint of residue content. Therefore, integrated pest management (IPM) strategies are essential to control pests, but at the same time reduce the use of
pesticides. Prediction of diseases, based on the monitoring of environmental conditions, can reduce significantly the use of pesticides. Biological control is becoming important in reducing insect and disease population, and thus also reducing the use of pesticides.

Fig. 6 Dropped fruits (common in Egypt) are a major source of insect infestation.
Quality

The quality of Egyptian mango for export is still very low. There are several reasons that contribute to such low quality. For example, latex flow, which is considered a major defect in the export market, is not considered a disadvantage for fruit picked for local market. On the contrary, it is sometimes considered as an index to freshness, and recent picking. Latex causes burning of fruit skin, deterioration of fruit color, and even health problems for some allergic pickers and packers.

Fruit is commonly picked at an over-ripe stage, to the point where it is sometimes picked only when it is dropped on the ground. This is done to accomplish the highest content of sugars, least acid content, and most intensive aroma. In some cases picked fruits were found to contain up to 23% total soluble solids. External market requirement is less than half that amount.

Fig. 7 Fruits are commonly picked over mature.
Soluble Solids Content in Some Egyptian Cultivars

There are certainly some big differences in the total soluble solids content of the different Egyptian cultivars at harvest, however it is usually significantly higher than requested by export markets.

For example, total soluble solids of ripened Taymour fruit was found to be about 18%. In the second week of August in Fayoum, mature-green Mabrouks fruits had 11.5° Brix and ripe fruit of the same cultivar had 16° Brix, while mature-green ˚weis´ had 12.5° Brix and ripe fruit of the same cultivar had 23° Brix. On the same date at Umm Saber, mature-green Pairi fruit had 8° Brix, medium ripe fruit had 17° Brix, while ripe fruit had 18° Brix.

Total soluble solids for tree-ripe Tommy Atkins fruit was found to be 15.5%, a value lower than almost all other local cultivars.

Fruit picked at a very late stage of ripening does not withstand postharvest handling. In fact, it is extremely common to see that during the postharvest chain in Egypt, most fruit has some kind of quality defect.

Mechanical injury is very common, and is commonly present in a major part of the fruit. This usually originates during harvesting due to dropping of fruit, mishandling (very rough handling) of fruit right after harvest and during separation of different cultivars in the packing shed. Major mechanical injury also originates during the very rough and mishandling of fruit during packing. It is common that fruit is dropped from different distances during packing.

Fig. 8 Several defects are commonly found in marketed fruit.
Almost all fruits are injured when in the packages, due to the use of either wood baskets without liners for protection, big corrugated cartons (12-14 kgs), and the common practice of overfilling.

Pickers and packers should be trained to eliminate this defect. Quality improvement of fruit should not aim only at the export market. A total quality control system in preharvest and postharvest should be implemented for mango production whether it is intended for the local market or for export.
Maturity and Harvesting Indices

The selection of adequate maturity indices is very important. The quality in postharvest and the postharvest life of mango fruit (as is the case with all other fruits) is strongly dependent upon the stage of maturity at harvest. Fruit has to be harvested at the ideal stage in order to develop the most adequate organoleptic quality and the longest postharvest life. Less mature fruit is usually more sensitive to chilling injury in postharvest. Fruit harvested before it reaches full maturity may not be ripened adequately after harvest, or in some cases (when harvested immature) it will never ripen. On the other hand fruits harvested when over-ripe are very sensitive to bruising, decay and to water loss and quality deterioration, and will not have a long postharvest life. In addition, fruit harvested over-ripe will show defects, such as jelly seeds or jelly pulp very shortly after harvest, and major quantitative and qualitative losses will occur. Jelly seed, which shows in large quantities of fruits and especially those picked over-ripe, deteriorate the internal quality of the fruit.

Fig. 9 Fruit is commonly picked at different stages of maturity.
Usual Practice in Egypt

Mango fruit for local markets in Egypt is usually harvested nearly ripe, and sometimes even over-ripe. This is usually determined by changes in color and/or softening of the fruit. It is common also that fully ripened and senescent fruit is easily dropped from the tree, and is sometimes considered as an index for ripening and thus for picking.

Total soluble solids of picked fruit was measured above 17%, a value almost double than that needed in different export markets.

In some varieties such as Golek and Aromanis, fruit is cracked when fully ripened on the tree, and therefore usually harvested before it reaches full ripeness, and is commonly ripened off the tree before it is sent to the market.

Recommendations Regarding Maturity and Harvesting Indices

Fruit, especially for export, should be harvested earlier in Egypt. The time for harvesting should be established on the basis of the type of market, distance from the orchard or the packinghouse, and the type of transport to be used.

For example, for Arabic markets, and where customers are accustomed to ripe fruits, and where the distance is short, fruit can be harvested between full maturity and early
stages of ripeness. Fruits intended for the European market should be harvested right after full maturity if they are to be transported by sea, and can be harvested at the early stages of ripening (half ripe) if the fruit is to be transported by air. This can also be applied for fruit intended for local market. Fruit to be sold in distant markets inside the country needs to be maintained for a few days or weeks before it is sold should be harvested shortly after full maturity. Fruit intended to be consumed very close to the orchard can be harvested at the later stages.

Fruit should always be harvested after full maturity and before full ripeness, but should never be harvested over-ripe for any market.

Several methods can be used to determine the optimum maturity stage and thus the ideal harvesting time. These should be investigated and selected according to the variety and growing region.

Maturity indices should comply with several requirements:
1. Easy to determine.
2. Should not be influenced by environmental conditions.
3. Should relate to maturity and quality of the fruit.
4. Should be objective if possible.
5. Preferably non-destructive.

It is important to define at least two sets of maturity indices:
1. Maturity indices for fruits harvested when ripe and intended for immediate consumption in nearby markets and for processing (late harvest).
2. Maturity indices for fruits harvested when physiologically mature and intended for storage or transport to distant markets (such as export markets) (early harvest).

Several methods are being used to establish maturity indices in different mango growing regions, including:
1. Computation (days from flowering, days from fruit set).
2. Development of shoulders.
3. Peel color.
4. Pulp color.
5. Softness of cheeks.
6. Specific gravity.
7. Starch content.
8. Dry matter.

Several of these factors have commercial applications only for a specific type of harvest (early or late) and for specific cultivars. Some of these factors are only applicable for fruits that have reached an advanced degree of ripeness. Some factors are also cultivar-specific.

**Computation, chronological**

Generally, harvest maturity in mango is reached about 12 to 16 weeks after fruit set. Computing the age of the fruit is one of the simplest factors that can be used for harvest. This factor is used in some mango-growing regions in Asia. It is calculated from full bloom and fruit set, and recommendations are made as to the minimum age at harvest for different cultivars in different regions. Minimum age for harvest differs for the same cultivar grown at different regions, due mainly to pre-harvest factors such as environmental conditions. Days from full bloom is most recommended, since it is the most easily standardized factor. This should be investigated as a possible maturity index for some mango cultivars in some regions in Egypt.

**Physical attributes**

Many physical, subjective attributes are used by mango growers as an indication of maturity changes. These include the shape of the fruit, the appearance of powdery material or bloom on the surface of the fruit, the appearance of plant sap on the surface, changes of the color of the stem, etc. The most important of these, which is used in several regions, is the position of shoulders in relation to the position of the stem end of the fruit. The rise of the shoulders above the stem end is an indication for fruit maturity. This also should be investigated to determine whether it can be adequate as a maturity index for some cultivars in Egypt. Some of the Egyptian cultivars where this index can be used include Dabsha and Company.

**Color**

The loss of green color is one of the most obvious signs of fruit ripening in many mango cultivars. The development of the optimum skin color is very important for fruit quality, since it is an important factor by which most consumers define mango quality. Some mango cultivars do not change color. In many mango cultivars the skin color changes from dark green to olive green, sometimes reddish, orange-yellow or
yellowish hues appear from the base color, depending on the cultivar. Some cultivars also develop a reddish blush, which has been attributed to anthocyanins. Color change in mango fruit is due to the disappearance of chlorophyll and the appearance of other pigments. Chloroplasts are transformed to chromoplasts. In yellow cultivars, carotenoids and xanthophylls are the predominant pigments. The anthocyanin phenodin-3-galacytosa has been identified in the skin of some mango cultivars. During ripening of mango, chlorophyll concentration decreases, carotenoid concentration is increased, and anthocyanin concentration stays stable or only increases very slightly. In mango fruit a substantial loss of chlorophyll in the peel is noted after the fruit begins to soften. That’s the reason why peel color is not an adequate maturity index, since when the change occurs the fruit is already soft.

The pulp of mango fruit contains a high concentration of carotenoids (up to 9 mg/100 g), and so it usually develops an intense yellow to orange color, and therefore mango is a good source of vitamin A. The pulp carotenoid level varies among the different cultivars.

Skin color is variable for different cultivars. Yellow cultivars develop their skin color somewhat uniformly, however cultivars with other colors are not uniform in their color development. In addition, some cultivars do not change their green color. Fruit position on the tree can affect peel color development. Nitrogen fertilization affects significantly the development of yellow and red colors.

Peel (skin) color is not the most adequate index, since most of the Egyptian varieties ripen with a green peel color. In a few of the varieties that change their peel color during ripening, such as Sukkary, the yellow color is usually developed much later than when fruits reach full maturity and thus cannot be used as an index for earlier picking. The change of skin color in these cultivars from dark green to light green is not an obvious index that can be noticed easily and used as a maturity index. Red blush on the skin of some cultivars, such as Pairi, is not a consistent change and thus can not be used as a maturity index.
Postharvest Handling of Mango

Fig. 11 Peel color change is not an adequate maturity index in Dabsha balady. Notice the skin burning with latex.

Fig. 12 Red blush in Alphonse fruit can not be used as a maturity index.
Fig. 13 Alphonse fruit with different skin coloring than that shown in figure 12.

Fig. 14 Changes of peel color in Company fruit due to ripening. The major change in skin color occurs after ripening and not immediately after full maturity.
On the other hand, in most mango cultivars, flesh (pulp) color changes are somewhat uniform when fruit advances in maturity. Unfortunately this is a destructive index, but more consistent and more utilized than skin color change. Flesh color is commonly used as a maturity index in several mango growing regions.

Flesh color will most probably be an adequate index for some Egyptian cultivars. Research should be initiated to determine the possibility of establishing this as a maturity index. For now, the only method of determining flesh color is by cutting the fruit. However, the development of non-destructive methods would certainly provide a very useful method.

Pulp color changes do not seem to be an adequate index for varieties such as Zebda, Dabsha, and Eweis, but seem to be a good index for Golek, Hindi Khassa, and Mabrouka. In these varieties, flesh color changes do not seem to correlate adequately with changes in maturity and ripening, and also do not seem to correlate with external changes in fruit shape and color. Pulp color changes from greenish yellow to yellow to orang.

Fig. 15 Pulp color change in Dabsha is not an adequate maturity index for this cultivar.
Fig. 16 Pulp color change might serve as an adequate maturity index in Golek.

Fig. 17 Pulp color change is not very consistent with skin color and ripening in Eweis.
Fig. 18 Pulp color changes progressively with fruit maturity in Hindy Khassa, and might serve as a maturity index.

Fig. 19 Pulp color in Mabrouka fruits seem to be an excellent index of maturity. Notice that peel color is not an adequate index.

It is very important to remember that these observations were made in a very short period (about 10 days). Extensive work should be done in all the growing regions and for several seasons to establish these indices.
Specific gravity

As mango fruit matures it accumulates dry matter and thus become denser. Therefore specific gravity may have some value as a maturity index. Specific gravity usually changes, although slightly (0.97 to 1.04), which in some cases makes it not a very reliable maturity index.

Soluble Solids and Titratable Acidity

During maturation soluble solids increase and titratable acidity decreases. However, there is no major use of these attributes as maturity indices for mango yet. In several cultivars, changes were either inconsistent or too small to be used as a commercial maturity index.

Total soluble solids (°Brix) is used in some cases as an index of quality and maturity, and mostly as a compliment to other indices such as shoulder formation and pulp color. Most markets require mango to be harvested with about 9 to 11% total soluble solids.

Most Egyptian mango cultivars are characterized by a very strong taste, and thus soluble solids, and possibly titratable acidity, might serve for some of these cultivars as maturity indices. These two factors should be included in future research.

Little research work has been done in Egypt to investigate the adequate maturity indices of Egyptian cultivars. Hussein and Youssef (1972) found that Mabrouka and Pairi mangoes reached legal maturity in Assiut in late August at the 18th week and early August at the 16th week, respectively. These researchers also believe that total soluble solids, total acidity, and the sugar/acid ratio are good criteria for determining the maturity stage. A gradual development of peel color was noticed in Pairi when stored at 25°C, but this decreased when fruit was stored at 7°C or 4°C (Serry, 1997).

Due to differences among mango types, diversity of cultivars, and diversity of production conditions, there is no consensus on maturity indices.

It is important that maturity indices be established for cultivar, growing region, and purpose of harvest (immediate consumption, local or export markets, storage, etc).

Mango fruit transported to distant markets by sea should be harvested firm and without any sign of color change. The fruit should be picked, treated, packed and shipped while still green and with a firm texture, and should arrive at the retail market more yellow or red than green but still firm.
Maturity indices for most cultivars (especially those of the Florida type, such as Haden, Tommy Atkins, Keitt, Kent), are based on:

- Position and thickness of the shoulders.
- Color of the pulp close to the seed.

Conditions that are usually applied to these cultivars are:

- Completely mature: formed shoulder, a depression around the peduncle, firm, and green color.
- Less mature: shoulders in line with peduncle, firm, and green color.
- Immature: shoulders in line with peduncle, firm, and green color.

It is both necessary and very common that several indices be used together in a complimentary manner to make a better decision.

Experience with the cultivar and growing condition is very important to determine the ideal maturity index or indices to use, optimum maturity stage and the optimum harvesting time.
Harvesting

Practice in Egypt

Poor harvesting techniques can affect very negatively the good work of the whole season. Picking of fruit before or after the ideal picking date, and any of the practices that result in bruising and damages to the fruit affect the quality of the fruit.

![Image of bruised mango]

**Fig. 20** Bruising of fruit due to inappropriate harvesting and dropping is very common.

It is very common that mango orchards in Egypt are a mix of different cultivars. Farms with segregated varieties are very rare. There are even a very few cases where several trees were found to carry more than one cultivar. This practice has several
disadvantages, mainly the difficulty of coordinating agricultural practices and harvesting.

Different cultivars mature and ripen at different times, and therefore pickers are forced to cross the whole farm every day for the whole season to look for fruit ready to be picked. This is very inefficient and extremely expensive.

In addition, when the orchard is mixed with early and late cultivars (common practice), agricultural practices (for example pruning) that should be done immediately after harvest are delayed for the early varieties until late varieties are picked.

Harvesting is commonly done by pulling the fruit by hand in the lower part of the tree, and pulling it with a hook connected to a long pole for fruit in the upper part of the tree. The use of a hook without a net is very common in Egypt.

![Fig. 21](image)

**Fig. 21 The long pole with the hook commonly used for mango fruit picking.**

Pulling the fruit, in addition to dropping it, results in leaving it without a stem, and that increases problems of latex flow, water loss, and decay. The hook, without a net,
also pulls the fruit and cuts it without a stem, resulting in problems similar to pulling of the fruit by hand. In addition, fruit picked by the hook is always dropped and severely injured.

In a very few cases scissors are used to cut fruit in the lower part of the tree. This is a much better practice since it can leave a longer stem and thus reduces postharvest problems.

In a very few farms, a pole with a net at the end is used to pick fruits from the upper part of the tree. However, most of these nets are not prepared to cut the fruit, but rather to pull it. Therefore, although the net receives the fruit and prevents dropping it on the ground, it does not allow cutting it with a stem.

![The type of net used in Egypt.](image)

Dropped fruit is commonly picked during harvest. These fruits commonly have major decay problems after harvest, especially when the fruit is ripened off the tree. Defects related to picking and dropping of fruit are commonly found during marketing.
Fig. 23 Fruits picked after being dropped. Notice decay and insect infestation problems.

In a few cases trees are shaken and dropped fruits are picked up from the ground. This practice causes very serious damage and losses to fruit and to the tree, and should not be done.

Fig. 24 Climbing of the tree for shaking and dropping of fruit.
Fig. 25 Mango fruit in the market with various defects.

Fruit bruising and injury is an extremely serious problem in harvested mango fruit in Egypt. It is rare to find unbruised fruit in the market. It has been argued that decay, especially anthracnose, which is commonly a latent infection, is not a major problem in Egypt. This might be true from the standpoint of preharvest environmental condition. However, major quantities of fruit in the market show decay problems. No identification was done, but it is clear that there was probably anthracnose infection. This problem is most probably due to the infection of fruit after harvest due to over-ripeness, bruises, and cuts. Over-ripe, cut and bruised fruit is easily infected with different decay causing organisms including *Aspergillus*, *Botryodiplodia*, *Diplodia natalensis*, etc.

Therefore, the avoidance of injuring the fruit would prevent several problems, including a significant reduction in decay.
Mangoes in Egypt are usually picked at all hours. However, it is important that fruit be picked at hours when temperature is not high. This would reduce field heat in the fruit and thus would maintain it for longer periods. Cultivars with high latex content should not be harvested very early to reduce latex flow.

**Recommendations on Harvesting**

Cultivars should be grown separately in the field to facilitate cultural practices and harvesting.

In young trees, and in the lower parts of old and vigorous trees, picking should be done by hand with the help of scissors. However, in higher branches some harvesting aids are needed to assist in picking. Several devices are being used in different regions in the world and can be established in Egypt. The most common device is a half-elliptical basket attached to a long pole adapted with a severing blade or scissors. The upper end of these baskets usually contains a heavy-gauge looped wire or scissors controlled by the picker to facilitate the separation of the fruit. The basket should only be big enough to hold a maximum of 3-5 fruits. This way fruit will not be injured either mechanically or by latex. Baskets should be made of a material (like cotton) that facilitates cleaning. It is important that these devices be designed so that about 2-3 cm of the peduncle of the fruit remains attached after harvest. This should be cut to about 1 cm during packing, because they can break again causing the flow of latex which can increase disease infection. Ladders or three-wheeled motorized picking platforms (known in some parts as cherry pickers) are employed in some regions to pick fruits from tall trees.

Fruits should be handled very carefully and should never be dropped in any manner. They should be emptied very carefully from the harvesting basket to the collection basket or box. Then they should be emptied very carefully in the packing shed (without dropping) in an adequate package.
Fig. 26 Mangoes in Egypt are usually picked in different types of baskets and carried to the shed.

Fig. 27 In one farm harvested fruit is collected in smaller size field boxes and carried to the shed using these crates.

Harvesting should be done by experienced pickers. The quality of the picked fruit will be greatly influenced by the ability of the picker to choose adequate (mature)
fruit and by the method of picking used. Fruits should not be picked all at the same
time, especially when harvesting is done at earlier stages of maturity. Repeated
harvest of the same tree should be carried out to ensure that only mature fruit is
picked each time.

It is very important that care be taken to reduce mechanical injury. Mechanical injury
during harvest is, unfortunately, common and causes major quantitative and
qualitative losses in the Egyptian mangoes.

Harvesting date should be chosen very carefully so that:

- Fruit arrival to the market is during the time of peak demand and highest price
  (usually the start of the week).
- It maximizes the chance of early sale and minimizes load waiting at the shipping
  port or in the market.

The time (hour) of harvest should be selected carefully. One should weigh the
benefits or not of picking in the coolest hour of the day. From the standpoint of field
heat, respiration, and heat damage, the fruit should be harvested in the
earliest/coolest hours of the day. Harvest during warm hours will increase fruit
deterioration, increase the need of fast cooling, increase energy requirement for
cooling, and negatively affect worker comfort. However, as mentioned elsewhere,
latex flow can be higher in the coldest (earliest) hour of the day.
Latex

A major percentage of fruit marketed locally in Egypt is stained with latex. Latex flow causes several problems including skin injury, prevention of adequate development of color, and promotion of decay. This problem is made possible when the fruit is cut without a stem. Latex will not usually exude from a longer stem because there is no continuity between the fruit and the stem resin ducts.

In addition to reducing the quality appearance of the fruit (burning of skin, influence on the development of natural pigments), latex can be injurious for people, especially to pickers and packers. Mango latex is reported to cause skin disorders in allergic humans. It has been suggested that the allergic material in mango is the 5-substituted resorcinol, causing mango dermatitis. Harvesting and packinghouse personnel should avoid contact with the latex. Workers who are allergic to mango latex should be assigned to other duties.

The flow of latex is augmented when the fruit is picked very early in the morning, or right after rainfall.

Cultivars differ in the flow of latex and in the extent of damage caused by latex. High nitrogen content in the fruit has been associated with more severe latex burn. Latex burned fruit skin can be invaded with *Aspergillus* spp., especially in hot conditions.

Adequate handling operations that can reduce latex flow should be practiced. These practices include picking fruit with a stem, washing of fruit, packing fruit on a table and not on the ground, and packing stem-up in the package.

Several methods have been tried to eliminate the latex on mango, including:

- Treatment with 1% solution of calcium hydroxide.
- Washing fruit in 1% aluminum potassium sulfate.
- Applying surface coating to fruit prior to eliminating the latex (desaping).
- Trimming and desaping at the packinghouse followed by inversion on a stationary rack or a roller-conveyer running below water or water and detergent sprays for 20 minutes.
Handling in the Field

Accumulation of fruit in the field

Due to the fact that most mango orchards in Egypt consist of a big mix of cultivars, pickers are accustomed to harvest different cultivars at the same time. These fruits are then accumulated in a shed where they are separated into the different cultivars.

Fruit is commonly accumulated on the ground in a shed for several hours and up to 2 to 3 days with the stem down. This is done mainly to reduce the flow of latex, and also to advance ripening. Temperature inside the shed is commonly very high (depending on the outside temperature), and was found in some cases to be higher than outside. Evaluation of fruit in a packing shed at one of the orchards in Ismailia showed that fruit temperature in the shed ranged between 37.1 and 42.5°, and ambient temperature of the shed at the same time was 38.8°, while relative humidity was 41%. Problems caused to the fruit by holding at high temperature for a prolonged period include advanced and uneven ripening and senescence, water loss, and decay infection and development. In addition, the contact of the fruit with the ground increases decay infection.

Fig. 28 Accumulation of the fruit on the ground.
Physical injury of fruit is common at all stages (harvesting, selection, packaging, transport, marketing, etc). This problem is clearly shown when the fruit is opened for consumption. Mechanical and physical injury should be reduced during all stages of handling.

Harvested fruits should be transported to the packinghouse or to the market as soon as possible. Avoid prolonged exposure in the sun, in the field, on the road, in the packinghouse, or at the market.

Fruits should be transported with care so that mechanical injury is minimized. Drivers should follow smooth roads, vehicle tires should be correctly inflated, and vehicle suspension should be a good condition.

It is preferable that mango fruit be handled in a packinghouse. At the packinghouse, if fruit needs to wait before packing, it must be set in a shed and protected from the sun,
high temperature, wind, and rain. Fruit should be packed within about 3-4 hours from arrival.

At least one central packinghouse for mango should be installed so that a sufficient quality of fruit can be accumulated and fruit can be handled and packed adequately. Some of the important mango growing regions in Egypt are relatively close to each other (Ismailia, Sharkia, El-Giza), and thus this suggested packinghouse can be established somewhere in between. Another alternative is the use of the facilities of an established packinghouse used for other fruits or vegetables which can be used off season during the mango harvest. This is the case for some packinghouses such as El-Hoda. In this case some modifications should be made to the packing line.

It is preferable that the peduncle be cut at this point to leave about 0.5 cm. Samples should be taken to evaluate quality of the fruit. This inspection is very important to determine the condition of the fruit, determine acceptance, suitability for a determined market, the treatments that the fruit should receive in the packinghouse, and decide to the price on bases of quality evaluation.

If an infestation quarantine treatment is needed, a sample should also be evaluated for the presence of insects.

It is recommended that fruit be received in water and transported on a roller conveyer to the other steps of the packinghouse. Water can contain up to 200 ppm chlorine and fruit should be exposed for 3-5 seconds. Chlorine is degraded easily and thus its concentration should be monitored regularly.

Fruit should be dried by air (fan) and/or by the use of brushes.

The packing line should be designed so that it can be comfortable for workers and does not injure the fruit. Light and temperature should be controlled.

There are many types of designs for packing lines and packinghouses, some are very simple while others are very detailed. However, the most important consideration is that the packing line should not be complicated, should not damage the fruit, and the process should be clean and organized. The line should be designed so that the process is logical, continuous, and synchronized.
Disease

Decay is usually one of the most important causes of postharvest losses in mango. Mango fruit is infected by several diseases. The most important of those include:

1. Anthracnose (*Colletotrichum gloeosporioides*). This is the most serious disease in most mango growing regions, especially those with high rainfall and humidity. Infection can be on the fruit, but also on blossoms, leaves, twigs and young branches. In addition to attack through the wounds, the organism can penetrate the fruit through the cuticle and natural openings on the fruit surface. In the fruit the infection is latent and starts to develop as the fruit advances in its stage of ripening. Although there are indications that anthracnose is not commonly found in harvested mango fruit in Egypt, there are more possibilities that infection does exist after harvest due to harvesting the fruit when over-ripe, the severe mechanical injury that the fruit receives, and the very limited use of refrigeration.

2. Stem-end rot (*Diplodia natalensis*). Stem-end rot is second to anthracnose in importance in many mango growing regions. The disease usually starts at the stem-end of the fruit but the fungus can also attack any part of the fruit, especially that which becomes injured during harvesting or handling. Infection can be reduced leaving a stem of about 1-2 cm.

3. Other diseases. Other diseases that can attack the mango fruit in postharvest include, Rhizopus (*Rizopus oryzae*), scab and sooty mold (caused by *Cannodium mangifera*). Rhizopus is usually a result of mechanical injury. Alternaria rot, which is caused by *Alternaria alternata*, can cause serious losses when anthracnose and stem end rot are absent. Black mold, which is caused by *Aspergillus niger*, can also infect mango.

![Fig. 30 Decay infected fruit, most probably due to mechanical injury.](image)
Disease Control Treatments

Decay control is accomplished with an adequate preharvest and postharvest integrated program. In postharvest, washing water usually contains about 100 ppm of sodium hypochlorite. It also can contain fungicides depending on the extent of the problem. Careful handling of the fruit, elimination of mechanical injury, rapid cooling, maintenance of low (optimum) temperature, and maintenance of hygienic conditions are essential for decay control.

Long hot water treatment used for insect disinfestation can also control some pathogens. However, fruit that does not have to be treated with the long hot water systems for insect control (fruits exported to the European market) can be exposed to hot water (with or without fungicides) for a short period for the control of decay.

Short hot water treatments used for decay control consist of temperatures of 48-55°C for 3 to 15 minutes, depending on the variety and the extent of the problem. Haden and Tommy Atkins mangoes are treated for about 3 minutes.

Treatment is applied right after receiving and washing the fruit in ambient water. Immediately after hot water treatment, fruit should be cooled in ambient or cold water.

Hot water temperature should be controlled and water should be circulating to maintain temperature uniformity.

Hot water is more effective for the control of anthracnose than for stem end rot. Shorter treatments are sufficient for anthracnose (about 3 minutes), while stem-end rot usually needs longer treatments (7 minutes or more).

Hot water tanks are of different sizes. They should be built from materials that do not react with any of the chemical material, are resistant to corrosion, and easily cleaned. These tanks are usually made of fiberglass, plastic, stainless steel, or steel with a protected cover. Tanks should be equipped with temperature control devices, and water should circulate to maintain in a uniform temperature. Tanks should be equipped with filters to avoid accumulation of soil, debris, etc.

Heat treatments, either hot air or hot water, are preferable because they are non-chemical treatments, they can delay ripening and senescence when used adequately (and thus delay development of diseases), and they can increase resistance of the fruit to chilling injury. Thus they are looked at as excellent alternatives for pesticide
treatments. In addition, hot air is compatible with the use of controlled atmospheres for disease and insect control.

Fungicides are sometimes needed, especially when a hot water treatment is not used. However, when combined with hot water, the effectiveness of penetration and action of the fungicide increases at high temperature. The combination of fungicides at high temperature can reduce the concentration of fungicide applied. The most common fungicide used in mango is Thiabendazole (Mertec). Mertec 20S is usually more preferable than Mertec 45, and concentration used is about 400 ppm.

Benomyl is added to the water (500-1,000 ppm) and replaced regularly. Benomyl is not registered in the USA for postharvest use, but it is still registered in other countries. Under neutral conditions, benomyl decomposes rapidly to carbendazim (MBC), but under alkaline conditions it converts to 1, 2, 3, 4-tetrahydr-3-butyl-2, 4-dioxo-s-triazino (alpha)-benzimidazole (STB) within a few hours. The antifungal activity of MBC is almost equivalent to that of benomyl but STB has no antifungal properties. In the water tanks, the accumulation of latex may increase the pH and result in the conversion of benomyl to STB rather than MBC. The alkalinity of the latex may also lead to the lower efficacy of benomyl in controlling stem-end rot. MBC is less polar than benomyl and thus it does not penetrate the skin as efficiently as benomyl. Therefore, it is important that water be as clean as possible from latex. Hot thiabendazole (TBZ) was found to be as effective as hot benomyl in controlling stem-end rot, but had less control of anthracnose. Benomyl penetrates plant tissues better than TBZ or MBC. Imazalil in hot water was reported to result in complete control of anthracnose and stem-end rot in several mango cultivars, but also found to be inferior to benomyl. Prochloraz (250-800 ppm for 15-20 seconds) also provides good control of anthracnose and alternaria rot, but not an adequate control of stem-end rot. A combination of hot water and benomyl treatment followed by a prochloraz spray was found to be effective for the control of anthracnose, stem end rot, and alternaria rot. The FAO recommends that residue of prochloraz in mangoes should not exceed 2 mg/kg.

Although the maximum residue levels are estimated for the whole fruit, most of it is found in the skin. For example, in Kensington, residues in skin were found 7 days after treatment to be 17 mg/kg, 1.7 mg/kg in the whole mango, and less than 0.1 mg/kg in the flesh.
The next table shows the maximum residues (mg/kg) for prochloraz permitted in some countries:

<table>
<thead>
<tr>
<th>Country</th>
<th>Residue</th>
<th>Fruits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>5</td>
<td>Avocado, banana, mango, papaya</td>
</tr>
<tr>
<td>Belgium</td>
<td>8</td>
<td>Avocado, banana, citrus, mango, papaya</td>
</tr>
<tr>
<td>Germany</td>
<td>0.5</td>
<td>Banana, citrus flesh</td>
</tr>
<tr>
<td>Germany</td>
<td>5</td>
<td>Citrus, whole fruits</td>
</tr>
<tr>
<td>Germany</td>
<td>8</td>
<td>Banana, whole fruits</td>
</tr>
<tr>
<td>Germany</td>
<td>2</td>
<td>Avocado, mango, papaya</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>5</td>
<td>Avocado, banana, citrus, mango, papaya</td>
</tr>
<tr>
<td>Spain</td>
<td>5</td>
<td>Avocado, banana, citrus, mango, papaya</td>
</tr>
</tbody>
</table>

When fungicides and or wax are applied as a spray one should consider the number, type and distribution of the nozzles, and the time the fruit is exposed to the treatment.

When treatment is done such as dipping, the tank should be made of a material that does not react with any of the chemical material. The tank should be resistant to corrosion and easily cleaned.
Insects

Several insects attack the fruit of mango, including mango weevils, mango seed borer, and several fruit flies. Fruit flies are widespread. The Mediterranean fruit fly (*Ceratitis capitata*) is established in 95 countries including Egypt, and considered the most destructive among the many fruit flies in existence. Therefore several mango importing countries, such as Japan and USA, require quarantine systems for this insect.

The commonly quarantined pests in mango (depending on the importing country) include:

- *Cryptorhyinchus manguiferae* (Fabricius)
- *Coleoptera: Curculionidae*
- *Ceratitis capitata*
- *Anastrepha ludens*
- *Anastrepha obliqua*
- *Anastrepha suspensa*
- *Anastrepha serpentina*
- *Anastrepha striata*
- *Anastrepha fraterculus*
- *Anastrepha distincta*
- *Bactrocera tryoni*
- *Bactrocera dorsalis*
- *Bactrocera orientalis*

Measures to control insects include preharvest and postharvest programs. Preharvest programs include cultural practices, traps, chemical treatments, and the use of sterilized insects. Pre-harvest chemical control has been achieved using organophosphates and hydrolyzed albumen. This is usually based on baited traps and the appearance of the first trapped males. The chemical control agents are dimethoate (0.1%) and fention (15%). The bait spray is based on Neziman (1:1 protein hydrolysate: malathion 4 L in water). Weekly application of malathion is commonly used. Removal of fallen fruits is important to prevent build-up of Mediterranean fruit fly populations. Some biological controls, using parasitoids, are used commercially
for the preharvest control of some fruit flies. Postharvest treatments include the use of chemicals, low temperatures, high temperatures, and the possible use of controlled atmospheres, and irradiation, or combined treatments. The use of high temperature is the most commonly used postharvest insect control treatment for mango.
Heat Treatments

Heat treatments are not used in Egypt, but can result in several advantages. They can delay ripening and control decay and insects.

Heat treatments can be applied in the form dry hot air, humid hot air, or in the form of hot water.

Hot water is commonly used in several countries to disinfect mango from fruit flies. For this purpose the fruit is submerged in water at 46.1°C for 65 to 90 minutes, depending on type of mango and fruit weight.

Hot water treatments should be applied at the beginning of the packing line or packing process. They can be applied on a moving belt (most common and most practical), or in tanks.

However, these treatments should not be used when fruit is harvested over-mature or with serious bruises or mechanical injury, since that heat would augment these injuries.

Fruit should be cooled right after heat treatment, commonly with ambient water followed by forced air cooling.

Insect Disinfestation Treatments

In case fruit is to be shipped to a market that restricts the entry of certain insects and requires a quarantine treatment, it should be treated with a legal system established through an agreement between exporting and importing authorities.

Handling of the fruit should follow the protocol of the quarantine system. The protocol usually defines preharvest treatments and precautions, restrictions of type of fruit that can be treated, and fields from which fruit for treatment can be harvested, traps for insects in the field, integrated preharvest treatments and control systems, etc.

At arrival to the packinghouse where the quarantine system is applied, fruit that has been harvested according to the quarantine protocol should be sampled to assure the absence of insects (at any stage). Fruit found to be infested should not be treated or packed. In addition, it is common that quarantine protocols require that export be prevented from fields that produce infested fruits, until that infestation is corrected.
Quarantine systems using fumigants such as ethylene dibromide (EDB) and methyl bromide (MB) are not acceptable anymore by almost all importing countries.

The quarantine system commonly used for mango in many countries is the use of hot water or vapor heat.

**Hot Air**

The hot air is usually forced over the surface of the fruit which will slowly heat the pulp. When air at 50°C was forced over mango surfaces all stages of mango fruit fly, West Indian fruit fly, and *Anastrepha serpentina* were killed when the seed surface temperature reached 48°C. Mango fruit weighing over 700 g cannot be treated with this system.

Vapor heat was approved in Japan in 1986 for the importation of mango from the Philippines. This treatment requires that mango be treated with vapor heat until surface temperature is 46°C and seed temperature reaches 46.5°C and held that way for 10 minutes. A vapor heat treatment has also been approved for the control of the Queensland fruit fly in Kensington mango exported from Australia to Japan. The treatment consists in raising the pulp temperature to 46.5°C and holding it for 10 minutes. The USA also approved a quarantine vapor heat treatment for the control of Mexican fruit fly (*Anastrepha ludens*) and other *Anastrepha* species in Manila mango, and for mango from Taiwan infested with the oriental fruit fly.

**Hot water**

The use of hot water treatments as a quarantine system was intensified after the elimination of ethylene dibromide. In Mexico, for the control of fruit fly (*Anastrepha ludens* and *A. obliqua*), this quarantine system started in 1988 for fruit exported to the USA and Japan, and consists of immersion of fruit in water at 46.1°C (115°F) for 65, 75 or 90 minutes, depending on the weight of the fruit. This system is now widely used in different mango growing regions in Mexico, Central and South America, and the West Indies. By 1995 almost 90 plants had been installed in these regions with an estimated cost of 150,000 to 300,000 dollars/plant. This system did not reduce the mango export as it was thought, but rather increased it. For example, in 1986 (using ethylene dibromide as a quarantine system) Mexico exported to the USA 36,685 MT, worth 25 million dollars, while in 1993 (using hot water treatment) export was up to 94,439 MT, worth almost 72 million dollars. Other countries outside of America have started experimenting and using hot water quarantine
systems. It was also found to be effective in the disinfestation of several insects, other than the genus *Anastrepha*.

Hot water treatments can damage the fruit. In the first few seasons the treatment caused major fruit injury in Mexico. However, now the treatment is used much more properly and therefore the damage has been controlled.

After quarantine treatment, fruit must be introduced to an isolated, insect-proof area to prevent re-infestation. From here on (packaging, transport, etc) and until the fruit is received at the importing end, secure measures are implemented to prevent re-infestation.

After heat treatment, fruit is usually cooled with water at ambient temperature and/or forced air cooling. In Mexico, fruit is first cooled in ambient water (at temperatures of \(\leq 21^\circ\text{C}\)), packed, and then cooled with forced-air cooling.

**Table 4 Phytosanitary requirements for some countries;**

<table>
<thead>
<tr>
<th>Country</th>
<th>Phytosanitary requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>Approved treatment for fruit fly, area free of <em>Sternochetus gravis.</em></td>
</tr>
<tr>
<td>Canada</td>
<td>No phytosanitary certificate required</td>
</tr>
<tr>
<td>European Community</td>
<td>Phytosanitary certificate required</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>No restrictions</td>
</tr>
<tr>
<td>Indonesia</td>
<td>Phytosanitary certificate required plus grown in areas free of Queensland and Mediterranean fruit fly</td>
</tr>
<tr>
<td>Japan</td>
<td>Phytosanitary certificate required plus disinfestation schedule approved for nominated mango cultivars and fruit fly species</td>
</tr>
<tr>
<td>Malaysia</td>
<td>Must be free of seed weevil on inspection</td>
</tr>
<tr>
<td>New Zealand</td>
<td>Phytosanitary certificate required plus disinfestation approved for nominated mango cultivars and fruit fly species</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>Phytosanitary certificate required. Require destructive test of 2% of consignment for seed weevil, or field survey verification of block freedom</td>
</tr>
<tr>
<td>Singapore</td>
<td>No restriction</td>
</tr>
<tr>
<td>United Arab Emirates</td>
<td>Phytosanitary certificate required. Require destructive test of 2% of consignment for seed weevil, or field survey verification of block freedom</td>
</tr>
<tr>
<td>USA</td>
<td>Phytosanitary certificate required plus disinfestation schedule approved for nominated mango cultivars and fruit fly species</td>
</tr>
</tbody>
</table>
Table 5 Disinfestation treatments for mango exported to Japan and the USA.

<table>
<thead>
<tr>
<th>Importing country</th>
<th>Exporting country</th>
<th>Required treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>Australia (Kensington)</td>
<td>VHT (46.5°C, 15 min) (Qu,Me)</td>
</tr>
<tr>
<td>Japan</td>
<td>Philippines (Carabao)</td>
<td>VHT (46°C, 10 min) (Or,Me)</td>
</tr>
<tr>
<td>Japan</td>
<td>Taiwan (Irwin, Haden)</td>
<td>VHT (46.5°C, 10 min) (Or,Me)</td>
</tr>
<tr>
<td>Japan</td>
<td>Thailand</td>
<td>VHT (46.5°C, 10 min) (Or,Me)</td>
</tr>
<tr>
<td></td>
<td>Nang Klang Wun, Nam Doc Mai, Pimsen Dang, Rad</td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td>Mexico (Manila)</td>
<td>VHT (43.3, 6 hr)</td>
</tr>
<tr>
<td>USA</td>
<td>Mexico, Central America North of and incl. Costa Rica, Flat, elongated cvs, rounded cultivars</td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td>Puerto Rico, US Virgin Islands or West Indies (excluding Aruba, Bonaire, Curacao, Margarita, Tortuga or Trinidad and Tobago)</td>
<td>&lt; 400g:65min, 400-570g:75min</td>
</tr>
<tr>
<td>USA</td>
<td>Panama, South America or West Indies localities excluded above, flat, elongated cvs</td>
<td>&lt; 375g:65min, 375-570g:75min</td>
</tr>
<tr>
<td>USA</td>
<td>Taiwan</td>
<td>VHT (46.5°C, 30 min)</td>
</tr>
</tbody>
</table>

VHT = vapor heat treatment, Or = oriental fruit fly, Me = Mediterranean fruit fly

As is shown in the above tables, disinfestation treatments for fruit flies are not needed for fruit exported to the European community despite the large production of temperate fruit in regions free of fruit fly. Fly infestation has never been perceived as a threat because freezing winter temperatures throughout much of the region effectively prevent establishment of the insects. Canada also does not require fruit fly disinfestation of tropical products for the same reason. The USA requires that mango be disinfested using treatments such as vapor heat, hot air, or hot water.

It is important to note that prior approval to import is required by some countries. These import permits may cover multiple importation’s but usually require renewal every 3-12 months. Phytosanitary certificates must be issued by a government agent based on an agreement commonly done between export and import countries. Consignments found to contain quarantinable pests will be rejected, and will either be regressed or destroyed.
Irradiation

Fruit flies sterilized by gamma irradiation are used in several countries to reduce the fly population in the field.

The postharvest use of gamma irradiation, which is approved in several countries, has been tried in mango to control ripening, diseases and insects. Gamma rays at a dose of about 0.15 to 0.3 KGy has been found to delay ripening and sterilize insects. This treatment, although expensive and not accepted by some consumers, is being looked at as an alternative quarantine system. Third instar larvae of the Mediterranean fruit fly usually do not emerge from the pupae when treated with a dose of 250 Gy. Unfortunately only marginal disease control is achieved when mango is treated with doses lower than 1000 Gy. Mango is usually damaged with doses above 0.5 KGy. Irradiated food needs to be labeled adequately to inform the consumer.
Sorting and Grading

A major percentage of mango fruit in Egypt is sorted and graded on the ground in the shade at the end of the line of the orchard. Harvested fruit is accumulated and spread on the ground, sometimes over a layer of straw. Cultivars are selected, and fruit is spread there, stem down, for up to 2-3 days as a means of eliminating the latex. In this shade, fruit is severely injured due to common rough handling.

Fig. 31 Sorting and packing of fruit on the ground (for the local market).

Grading and sorting should be done on tables to insure a better work environment for workers and less problems for the fruit.

Fig. 32 At one farm, mango fruit is graded and packed on tables.
Fruit should be selected, and only good-quality fruit should be packed. The purpose of this step is to sort fruit into uniform categories (according to size, shape, color and ripening stage, and absence of defects), and to divert low-quality fruit to another use such as low-quality markets or processing. Fruit can be classified as different grades according to the requirements of the market. Defected fruit should be eliminated. This is done manually by a trained person. This area in the packing process should be designed to be comfortable in relation to height of selection tables, lights, temperature, etc.

Sizing is important to categorize fruits into different and uniform groups, either on the basis of size or weight. Mango fruit can be classified manually, but uniformity will be much better when sizing is done mechanically, either by size or weight according to the requirements of the importing market. Sizing can be done by using divergent arms, with the distance between them adjusted so that it is smaller at the beginning and increases and to a maximum at the end. Fruit is dropped depending on its diameter and the distance between the arms. Distances between arms are adjustable so that fruit sizes can be modified depending on the cultivar and the requirement of the market. Mango can also be classified by weight. This is a better method, since it produces a much more uniform classification. Sizers consist of plates controlled electronically. Each plate carries one fruit. When the fruit is dropped in the sizing plate, its weight is recorded, and the fruit will be dropped automatically in the packing band corresponding to its size.

Quality grading of mango fruit is usually done by manual inspection and observation of individual fruits by trained persons. Fruits are classified according to uniformity, maturity stage, color, absence of injuries and defects, latex stain, disease and pests infection.
Waxing can reduce water loss, improve fruit appearance, and can even provide an adequate internal modified atmosphere. However, waxing of mango is not commonly used because of the risk of anaerobic fermentation and off-flavor development. In Mexico, very few exporters apply waxing, especially after hot water treatment. Hot water treatment can remove bloom and natural wax, and that can increase water loss and the senescence of the fruit.

It is important to revise the regulation of the importing country to make sure that waxing is permitted, and to investigate the type of wax allowed. In all cases, wax should be of natural origin. If to be used, the wax should be applied in a thin uniform film, using preferably roller brushes or very light hand application. Dipping fruit in a wax emulsion is not recommended. The wax can be applied together with the fungicide. The fruit should be completely dry before applying the wax.
Packaging Practices in Egypt

Most packages used for mango recently in Egypt are made of corrugated carton. The packages used are general-purpose packages that are used for several fruits and vegetables. They are not designed for any specific fruit or vegetable in particular.

![Packages used for mango in Egypt](image1.jpg)

**Fig. 33** Some of the packages used for the local market. Most are used for different fruits and vegetables, and are large.

![Man holding mango packages](image2.jpg)

**Fig. 34** A few packages used in Egypt for the local market are small.
The re-use of packages is common. These, in addition to not being specific for mango, are usually characterized by a weak stacking force due to multiple use, and can be a major source of decay infection.

Packages commonly used in Egypt are big and heavy when are filled, with a capacity of 10 kg or more. These big packages result in significant fruit injury because of weight compression of upper fruits, especially if fruit is commonly picked over-ripe, and the package is commonly over filled. In addition, these packages are difficult to handle by workers and so are subject to mishandling and dropping, resulting in significant fruit losses.

Fruit packed is usually not uniform. Packages of Taymour fruit evaluated showed that in a package of 10 kg, the top layer had fruits averaging 357 g and ranging between 316 and 429 g, while the bottom layer had fruits averaging 280 grams and averaging 231 and 350 g. In this package 45.16% of fruit was bruised at the moment of packing, 48.39% had a major problem with latex staining, and 48.39% had a slight latex problem. At the same farm, and in a package of 10 kg of Eweis fruits, the average weight was 208 g and the range was 143 to 290 g. In this package, 26% of the fruit was bruised at the moment of packing, and more than 18% had different types of defects, such as rubbing and disease. At another farm, the evaluation of a package of Mabrouka fruits showed an average weight of 469.2 g, and a range of 397 to 558 g, and more than 40% (41.66%) of these fruits had serious latex staining problems.

In another orchard, the evaluation of a large (grade 1) amount of Pairi fruit packages showed that the average weight of the fruit was 385.45 g, and fruit ranged between 300 and 530 g. In this package almost 28% of the fruit was bruised, and 100% of the fruit had latex staining problems. In addition, 36% of the fruit had other defects including disease (18%), cuts (9%) and scarring (9%). Fruit of Pairi that are graded as small or number 2 had a top layer averaging 161.32 and ranging between 121 and 220 g, and a bottom layer averaging 146 g and ranging from 88 and 195 g. Ripe fruit in this package represented 62%, and those with different types of defects were 44%.

It is very clear that bruising and other defects are extremely high at the moment of packing, and will naturally increase significantly in the later stages of handling, especially when the fruit is exposed to extreme climatic conditions and not refrigerated.
Recommendations for Packaging

Packages used should be specifically designed for mango, and should be new and clean. They should be smaller than those commonly used in Egypt. Commonly used packages for mango in the international market have 3 to 6 kg capacity and are made of corrugated fiberboard. Packages with a base of 30 x 40 cm are most common for mango in Europe. The height of these boxes is about 10-12 cm, with about 10 mm of space left at the top to ensure better ventilation. The fiberboard should have a minimum weight of 300 g/cm². Packages can be either telescopic or with an open top. Telescopic packages should have double-lined vertical sides. Open-top packages should be reinforced on all sides. In addition, and in order to improve pallet structure, open-top packages should have stacking nubs on the top and corresponding slots on the bottom. Ventilation openings are recommended to be at least 8% of the overall outer surface area of the package. Common sizes for packages for a net weight of 4.5 kg (10 lbs.) of fruit are 10.9 cm x 34 cm x 26.9 cm and 10.2 cm x 43.2 cm x 27.9 cm. Smaller size packages, for 3 and 4 kg of fruit, are also being used.

Mango packages commonly used in the world are usually one piece cartons, and fruits is packed in a single layer.

Packages should be well ventilated, but with a sufficient stacking strength (a minimum bursting strength of 250-275 lbs per square inch). Ventilation openings are essential for adequate cooling and for heat and gas exchange.

Fruit in Egypt is usually packed with the stem down. This is done to prevent the flow of latex from contacting other fruits in the package. This practice, however, increases the flow of latex on the surface of the package, and sometimes it does get in contact with the fruits. It is more effective to pack fruit with stems up. This practice would reduce the flow of latex and allows for a better packaging appearance. This practice can be possible, however, only when fruits are cut with a sufficiently long pedicel.

Packing on the ground is not comfortable for workers, and neither is appropriate for the fruit. It should be done on tables that can offer comfort for packers and thus increase packing efficiency. In addition, this would decrease fruit deterioration and losses.

Some packers use cement papers as liners in the package. This material should be eliminated and substituted with other types of clean paper.
Fig. 35 The use of cement paper as liners in packages should be eliminated.

Fruit in the package should be uniform with regard to maturity stage, color and size. Only one size and one maturity stage should be packed in each package.

Each package should be identified and should carry information such as source of fruit, date of packaging, packer identification, etc. This information is very important to correct any problem that can arise during further handling steps.

Inspectors should check the efficiency of packing by withdrawing packages randomly and analyzing the content to make sure that it meets the requirements set for each package.

Fruit should be handled with care to avoid bruising. Different methods can be used to protect fruit bruising caused by movement in the package, by contact with the package wall or with other fruit. Fruit can be wrapped in protective sleeves made out of different types of polymers, or in soft tissue that can be of different colors to improve the appearance of the package in addition of protecting the fruit.

Mango fruit is usually packed by count, depending on the size of the fruit. Commonly packed sizes are 6, 8, 10, 12, 14, 16, and 18 fruits. Packages with 8, 9, 10, and 12 fruits are the most commonly in demand in Europe. In Germany, the most popular fruit size is 300-500 g, while it is 225-500 g in the rest of Europe. The package should be marked to show the number of pieces.
The package should be labeled and printed with sufficient information to protect and inform consumers adequately. The printed material should be clearly visible, easily legible, and made in an attractive manner using attractive colors, letter type and size. Some information, such as required storage and transport temperature and weight should be less conspicuous.

Packages should meet several requirements:

1. They should protect the fruit from mechanical damage and from contaminants, and not cause injury.
2. They should have a sufficient strength. These packages will commonly be in contact with a humid atmosphere, and that should not weaken the structure of the package.
3. They should be designed with sufficient openings for ventilation. This is very important for cooling of the fruit, and also to liberate respiration gases. Vents and opening in the packages should be in accordance with the direction of air circulation in the transport container.
4. They should be attractive, and should provide sufficient information including promotional data. The information needed to be printed on the package includes product name, source, and class. Packaging should be a marketing tool, and should portray an excellent marketing image.
5. Size and capacity of packages should be in accordance with the requirements of the market, and the available infrastructure, transport, shipping facilities, etc.
6. They should be easily opened and closed.
7. Preferably, packages should be recyclable.
8. Packages should be designed according with the requirements of the export market in regard to the material used and the size. Regulations of countries should be checked before using the package. Special attention should be given to the tendency of recycling in Europe, and the special materials and sizes in Germany. It is also important to use packages compatible with pallet to be used (for example 1.0 x 1.2 m for Europe or 40" x 48" for the USA).
9. The packages should be compatible to the handling system at the importing end.

In Europe, there is a strong trend toward recycling and standardization. Packages made of mixed products are to be avoided. Also try to avoid stapled products. Waxed packages are acceptable in the USA and some other markets, but are not acceptable
in the EC market, because they are not recyclable (unless waxes used are biodegradable and recycled). It is very important to communicate with the importer for the requirements of each country.

There is no use of pallets in Egypt for the local market, but rather the boxes are handled, stacked, and transported separately. Palletizing allows much easier, faster, and uniform handling, lower costs, and better utilization of space in the storage rooms or transport containers, and thus decreases fruit damage. However, this practice is only possible when the fruit is packed in a packinghouse. Handling of packaging in a pallet results in several advantages, including less rough handling of fruit, uniform handling, less delay in handling, and better use of space.

Pallets can be filled with either one or several sized fruit packages, depending on the order. It can also include a mix of different types of fruits (mixed load).

Pallet bases are different depending on the market. There are two Euro pallets, with sizes of 120 cm x 100 cm and 120 cm x 80 cm. Pallet size in the USA is 40 x 48”. International standards (ISO) for pallets are 100 x 120 cm. There is no standard for the height of the pallet, except that it has to meet the dimension of the transport container. Stacking of packages in the pallet depends on the type of pallet and the size of packages. Pallet tags should be used to show the date of palleting, type of product and cultivar, fruit size(s), and number of packages.

A standard 40 foot marine container can hold 20 pallets and 2,860 to 5,120 cartons, depending on the package size.

**Types of Packages Commonly Used for Mango in the World and their Characteristics**

**Bamboo and other types of wooden baskets**

These baskets have different shapes and sizes. They are usually used for collection, transport and marketing packages. The use of these baskets, especially for transport, presents several problems. They do not provide sufficient protection for the fruit, especially due to their shape and vulnerability for being distorted. Tests were done on some of these baskets, which were found to be characterized by compressive force that can cause excessive damage to the fruit. Due to the shape of these baskets it is difficult to stack them more than one layer high without the risk of causing excessive damage. Their shape is also a major disadvantage during transport because
it does not allow for a better utilization of space. In addition, some of these designs make them unstable and easily rolled off, and thus cause major fruit damage.

Fig. 36 Wood boxes commonly used for mango packaging in Egypt.

**Wooden crates**

These containers are used in some mango growing regions. In Mexico, almost all the mango intended for local market is collected, transported and marketed in these containers. It is also used for export shipments from Indonesia, Malaysia and Thailand to Singapore. In the Philippines it is used to ship mango from production areas that are far from the wholesale market.

These containers offer much better protection for mango than bamboo and wooden baskets. They are characterized by a rigid structure and can easily be stacked without deformation, thus without causing fruit injury. In addition, this type of package has the advantage of utilizing space adequately during transport, storage, and during exposition in the market.

These containers also come in different designs and sizes. The most commonly used in Mexico have a capacity of about 10 to 14 kg. In Indonesia, they have a capacity of 20 kg, in the Philippines a capacity of 15 kg, and in Malaysia wooden boxes have a capacity of 30-40 kg. Some producers in the Philippines also use a wooden box with a capacity of 60 kg.
These packages are not used commercially in Egypt. Their use could provide several advantages over to the type of packages now in use. Compared to the corrugated carton commonly used in Egypt for the local market (with a capacity of 14 kg), wooden boxes can protect the fruit better, do not cause as much injury, and stack better. In addition, these boxes can be used several times.

However, these containers should not be used for export because of their excessive weight, and because they are difficult to reuse, recycle, and print.

**Rigid plastic containers**

The trend toward using rigid plastic containers is increasing in different parts of the world. These come in different sizes, but the most commonly used have a capacity of about 10-20 kg. They are mostly used to collect fruit in the field (as field packages) and for transport to the packinghouse.

They have several advantages, including:

- Their rigid structure provides protection to the fruit.
- Easy stacking.
- Better use of space.
- Easy to clean.
- Multiple uses.

In Egypt, these packages (with a capacity of 10 to 20 kg) are used as field packages in some of the orchards. They should be cleaned very often to reduce decay infection of fruit.

**Corrugated cartons**

Exported mango from different parts of the world, especially those transported by air, are usually packed in corrugated fiberboard cartons. In Egypt, there is an increase in the use of these packages for both local and export markets.

These have several advantages over other packages, including:

- Light in weight, which results in better handling by workers and less expenses, especially during air transport.
- Smooth walls that cause less damage to fruit.
- Can be easily printed and thus can be attractive, and can show needed information for promotion.
- Their fabrication can be easily automated and their designs can be improved easily.
- They can be recycled.

However, these packages do not have enough stacking force compared to wooden boxes, and this force can easily deteriorate, especially by humidity (if they are not treated). This is especially true when big packages are used, as is the case for the ones used in Egypt. Net weight of these packages for mango usually ranges between 3 to 6 kg, depending on the specifications of the market.

**Package liners**

These are materials that can be placed on the sides, top or bottom of the package or between fruit to provide additional protection. Several materials are used in packages for the local markets, such as newspapers in Mexico, and rice straw in Indonesia. These can result in accumulation of heat and ripening of fruit. Package liners are important in Egypt fruit is picked at a ripe stage and due to the excessive mechanical injury.

![Fig. 37 Types of package liners commonly used in Egypt.](image)

A relatively expensive but very effective means of protecting individual fruit is to wrap them individually in a polystyrene mesh bag.
ISO standards

The objective of the International Standard Office (ISO) is to improve and facilitate the movement of products without difficulties in different countries. ISO standards are more applicable in some countries than others.

As mentioned, mango for export is commonly packed in a single layer in packages with a capacity of 3 to 6 kg (8, 10, 12 fruits according to size). The internal dimensions of these packages are usually about 33 cm x 30 cm x 10.5 cm.

The recommended force of the package should be 250 to 275 lb\textsuperscript{2} to avoid deterioration.

The information printed on the package is commonly:

- Type of product.
- Variety.
- Net weight.
- Country of origin (product of ____).
- Information (address, telephone, fax, etc.) of the exporter.
- Information of the importer.
- Recyclable.
- Some countries require information on special treatments, such as hot water treatment, and fungicides applied.
- Other information can include optimum handling conditions (optimum temperature, optimum ripening condition, etc.) and recommended methods for preparation and consumption.
Precooling

Mango fruit in Egypt is not pre-cooled, and there is very little use of refrigeration during transport, storage, and during holding in the market. Fruit is usually handled at ambient temperature from harvest until it reaches the consumer. Temperature during the harvesting period (June to September) is rather high. In addition, relative humidity is low in most areas. These conditions, in addition to the common practice of harvesting fruit at very late stages of ripening, are very harmful to the fruit and significantly reduce postharvest life. High temperature and low relative humidity cause several problems including increases in water loss, advance ripening and senescence, decay development, and an increase in the incidence and/or the intensity of some physiological disorders, such as jelly seed.

It is important that fruit, especially for export and especially after heat treatment (if used), is precooled to eliminate field heat so that it can be maintained for longer periods. Precooling is very effective in delaying fruit ripening and senescence, reducing water loss, and preventing or at least delaying the development of decay. The delay in cooling mango fruit results in accelerated ripening and in short postharvest life and poor quality.

The most appropriate precooling method for mango is forced air cooling with an air velocity of about 60-100 m/min. It is common, and very practical, to precool fruit right after packaging. Fruit is usually cooled to about 2°C above its optimum temperature (about 15°C). The time needed to achieve this temperature depends on initial fruit temperature, and temperature and velocity of precooling air. However, a period of 2 to 4 hours is commonly sufficient to reduce temperature from about 38°C to 14-15°C (temperature at which precooling should be terminated).
Ripening

Practice in Egypt

Ripening of mango in Egypt is commonly done in the field right after harvest and before packaging, by increasing the temperature of the fruit. This is usually done (in a process called KAMR) by either leaving the fruit exposed in a shed for up to two days on the ground, or wrapping fruits in newspaper and again in plastic. Temperature, especially around the fruit wrapped in newspaper and plastic, is increased very significantly, causing fruit senescence. In a shed at about 5 PM, the temperature in early August was measured at 39°C, and it was 3°C higher than the air temperature outside of the shed. Temperature of fruit wrapped in newspapers and plastic is sometimes higher than 40°C. These temperatures are very damaging to mango. Temperatures above 25°C cause uneven ripening. Temperatures above 35°C slow-down the ripening process by inhibiting the enzyme ACC oxidase that is responsible for the formation of ethylene. These high temperatures increase water loss and decay incidence very significantly.

As is the case with banana, acetylene is sometimes used in Egypt to ripen mango fruit. Acetylene is an ethylene analog, but needs to be applied in much higher concentrations than ethylene. In addition, the control of temperature and relative humidity is very critical for an adequate ripening process. The high temperatures (above 30°C) and low relative humidity (sometimes as low as 20%) commonly found during mango ripening in Egypt, do not result in an adequate ripening process, but rather in senescence and in deterioration of quality, including a major loss in weight and organoleptic flavor, and an increase in decay.

Some trials are being done by Dr. Awad Hussein from Alexandria University to ripen some cultivars such as Zebda at the 6 October wholesale market, using ethylene generators.

Recommendations Regarding Ripening

Mangoes are commonly harvested after full maturity but before ripening. Ripening of mangoes off the tree is not very common on the international market. However, those fruits harvested at the mature green or breaker stages, in order to withstand postharvest handling, can be ripened at the wholesale or retail level to improve their eating quality.
Ethylene, either in the form of gas or an ethylene generator, is the most efficient and fastest means of ripening mango. It results in the most uniform ripening process. Ethylene generators are much safer, easier to use, and cheaper in the long term.

It is important that the “ripening” process be distinguished from the “senescence” process, although they are very much related. “Ripening” is a much earlier stage than “senescence”. As is the case for many other fruits, ripening of mangoes off the tree is used to promote a “uniform ripening” and should not cause “advanced senescence”. Unfortunately, the result of the process of “el kamer”, commonly practiced in Egypt, is “advanced senescence” rather than “uniform ripening”.

If ethylene gas is to be used, safety must be considered very strictly. This gas is explosive at a concentration of 3.2% in air (32,000 ppm). Although this concentration is about 320 times higher than the maximum concentration needed to ripen mango fruit, the gas can accumulate to explosive concentrations that can result in major damage and danger to human life.

The uniformity of the process of ripening and the quality of the ripe fruit depend on several factors:

- Maturity of fruit at harvest. Fruit harvested immature will not ripen. More mature fruit will ripe faster and with less concentration of ethylene than the use of less mature fruit.
- Temperature of fruit to be ripened.
- Temperature during the process of ripening.
- Relative humidity during the process of ripening.

Temperature and relative humidity during the ripening process are extremely critical and must be controlled very adequately. Optimum temperature during the ripening process is 20 to 22°C, and optimum relative humidity is 90 to 95%. Lower temperatures, as 15.5 to 18.0 °C, can result in slower ripening, and in an attractive peel color but fruit flavor will not be adequate. Higher temperatures, as 27 to 30°C, can result in a faster ripening process, a mottled skin and a strong flavor. As mentioned earlier, temperatures higher than 30°C will retard ripening due to their inhibiting effect on ethylene production and action. Fruit temperature should be controlled at 20 to 25°C before the initiation of the ripening process.
A maximum ethylene concentration of 100 ppm is adequate for a uniform and fast ripening process. Lower concentrations can also result in ripening, but at a slower rate. Treatment duration is commonly 12 to 24 hours, depending on the initial stage of fruit maturity.

The accumulation of carbon dioxide at concentrations of 1% or higher around the fruit during ripening will retard the process, due to its competitive inhibition of ethylene. Therefore, adequate ventilation should be implemented to reduce the concentration of CO₂.
Transport

All mango transport to the local market in Egypt is done in non-refrigerated trucks and cars. Temperatures during the mango production season (July-October) are high, and thus non-refrigerated transport increases the deterioration of quality and causes major losses of fruit, especially when it is done inadequately.

Land non-refrigerated transport to local markets may be feasible if the distance is short, and the weather is not very warm. In warm weather transport should be done at night when the temperature is much lower. Non-refrigerated cars and trucks should be covered adequately to protect fruit from wind and high temperature.

Some of the mango exported to some Arab State markets is transported in refrigerated land transport units. Refrigerated land transport containers should be checked and adjusted before loading to insure that conditions and functioning are proper. Fruit should be loaded after cooling, and containers should also be pre-cooled before loading. Transport containers should be clean, and fruit should be stacked correctly to permit proper circulation of cold air and to prevent warming-up of the fruit.

Transport should not be delayed.

It is recommended that a sample of shipped fruit be maintained to evaluate its quality during the shipping and marketing period. This sample should be maintained at the same conditions (temperature and relative humidity) of the transported fruit.

Sea Transport

Sea transport of mango from Egypt is not yet commonly used.

Most of the mango imported to Europe from almost all countries other than Egypt (except Israel) is transported over long distances imported from distant countries such as Mexico, Brazil, Peru, the USA, etc. Egypt has the advantage of being much closer to very important markets. Marine transport is one of the keys that can facilitate the development of the export industry. Marine transport technology for perishable crops has gained several advances in the last few years, and therefore its use is increasing all over the world. Companies that specialize in perishable marine transport are increasing. The marine container industry and port infrastructure are improving. Several treatments can be applied on-board in sea containers including modified and controlled atmosphere, quarantine treatments, and ripening treatments.
The lower cost of marine transport compared to air transport has made possible the export of several lower-priced products. Standard 40 foot refrigerated container rates into Europe were estimated at approximately US $4,000 (ATUT, 1997). The resulting cost of a 4-5 kg carton is approximately US $1.00, significantly lower than the air freight cost. However, transport periods by sea are significantly longer and therefore crops to be transported by this system should be handled so as to ensure a sufficiently long postharvest life.

Ideally, mango should be packed directly at the packinghouse in the refrigerated marine container. The advantage of this practice is to reduce fruit handling and not interrupt the cold chain. However, if this practice is not possible, fruit should be transported by refrigerated trucks to the port.

The cold chain should be maintained and should not be interrupted at any time, including during transport. Loading and unloading should be done in a way that would not contribute to a major increase in temperature. Temperature recording devices should be installed in the most efficient location in the container.

### Characteristics of the Commonly Used Sea Containers

#### Refrigerated containers: 40' x 8' x 8.6'

<table>
<thead>
<tr>
<th></th>
<th>External measures</th>
<th>Internal measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>12,192 m (40&quot;&quot;)</td>
<td>11,151 m (36'7&quot;)</td>
</tr>
<tr>
<td>Width</td>
<td>2,438 m (8&quot;)</td>
<td>2,225 m (7'3&quot;1/2)</td>
</tr>
<tr>
<td>Height</td>
<td>2,590 m (8'6&quot;)</td>
<td>2,169 m (7'1&quot;3/8)</td>
</tr>
</tbody>
</table>

#### Reefer containers: 40' x 8' x 8.6'

Maximum weight of load: 25,080-25,980 kg. (55,301-57,286 lbs)

<table>
<thead>
<tr>
<th></th>
<th>External measures</th>
<th>Internal measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>12,192 m (40&quot;&quot;)</td>
<td>11,237-11,574 m (36'7&quot;-38&quot;)</td>
</tr>
<tr>
<td>Width</td>
<td>2,438 m (8&quot;)</td>
<td>2,239 m-2,286 m (7'4&quot;-7'5&quot;)</td>
</tr>
<tr>
<td>Height</td>
<td>2,591 m (8'6&quot;)</td>
<td>2,173 m-2,250 m (7'2&quot;-7'5&quot;)</td>
</tr>
<tr>
<td>Capacity</td>
<td>57.5-58.7 m³</td>
<td>(2,030-2073 cft)</td>
</tr>
</tbody>
</table>

#### Reefer containers: 40' x 8' x 9.6'

<table>
<thead>
<tr>
<th></th>
<th>External measures</th>
<th>Internal measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>12,192 m (40&quot;&quot;)</td>
<td>11,574 m (38&quot;)</td>
</tr>
<tr>
<td>Width</td>
<td>2,438 m (8&quot;)</td>
<td>2,282 m (7'6&quot;)</td>
</tr>
<tr>
<td>Height</td>
<td>2,895 m (9'6&quot;)</td>
<td>2,527 m (8'3&quot;)</td>
</tr>
<tr>
<td>Capacity</td>
<td>66.7 m³ (2,355 cft)</td>
<td></td>
</tr>
</tbody>
</table>

Some of the new marine containers are characterized by vertical air circulation, where cold air is circulated from below, in contrast to the horizontal air circulation normally used in containers for land transport and some marine containers (similar to
the system used for cold storage rooms). The vertical system is more efficient than the classical horizontal system in cooling the load. Cold air is forced through the packages to the upper part of the load. However, the package and the stack should be designed to be compatible with this system. It is important to insure whether the cold air circulation in the container is vertical or horizontal, to be able to select the adequate package and the stacking system.

Containers for land and sea transport should be:

- Clean, not damaged, with sufficient and functioning air ducts.
- Pre-cooled before loading the pre-cooled fruit.
- Refrigeration capacity should be adequate for the quantity of fruit to be transported.
- Containers should be equipped with thermometers (such as the Ryan system). There should be preferably more than one, and should be allocated in ideal places in the container, preferably inside the fruit pallet.
- Containers are designed to maintain the temperature of the load and not to pre-cool it (not to remove field heat).

There are four different refrigeration systems used for transport:

- Mechanical refrigeration. Containers are connected to electric energy aboard diesel trucks or ships.
- Cryogenic systems. In this system liquid nitrogen or carbon dioxide is introduced to the load.
- Dry ice. Solid carbon dioxide blocks are packed with the product. This is used during air transport. In addition to lowering the temperature, dry ice can also increase the CO₂ content around the fruit.
- Refrigerant gel. This is commonly used for air transport of perishables.

**Air transport**

Some fruit export in the world is still done by air shipments without refrigeration. Almost all the mango exported from Egypt to Europe is done by air. Transportation costs are usually very high. Air freight to Europe costs between $0.8 and $1.05/kg. The cost of air freight for a 4 kg carton of mango to Europe costs between $3.2 and
more than $5.00. These very high costs will not allow the Egyptian mango to compete in the international markets.

Air transport should only be used when fruit is to be shipped at an advanced stage of ripening or when fruit prices in the export market are high enough to justify it.

Transport to the airport should be done in refrigerated vehicles. The trip to the airport should be scheduled to reduce waiting periods at the airfield. Longer waiting periods will warm up the fruit and promote fruit ripening and reduce its postharvest life and quality.

Inside the plane and when aircraft compartment is not refrigerated, and especially if waiting periods are long and at high temperatures, there are ways to maintain a relatively low temperature around the fruit. Dry ice (solid CO$_2$) or refrigerated gels can be used.

**Table 6 Characteristics of air pallets and containers.**

<table>
<thead>
<tr>
<th>Type</th>
<th>Weight kg</th>
<th>Volume (m$^3$)</th>
<th>Dimensions (cm)</th>
<th>Max. Weight of load</th>
<th>Loaded in:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pallet</td>
<td>P1P/PAG</td>
<td>115</td>
<td>10.4</td>
<td>223x317x16</td>
<td>6,033</td>
</tr>
<tr>
<td>Pallet</td>
<td>P6P/PMA</td>
<td>125</td>
<td>4</td>
<td>244x317x24</td>
<td>6,804</td>
</tr>
<tr>
<td>Container</td>
<td>LD2</td>
<td>73</td>
<td>3.3</td>
<td>1,200</td>
<td>B747</td>
</tr>
<tr>
<td>Container</td>
<td>LD3</td>
<td>80</td>
<td>4.3</td>
<td>1,588</td>
<td>B747,A30</td>
</tr>
<tr>
<td>Container</td>
<td>LD9</td>
<td>120</td>
<td>2</td>
<td>2,400</td>
<td>0</td>
</tr>
<tr>
<td>Container</td>
<td>LD9/AAP</td>
<td>200</td>
<td>10.3</td>
<td>223x317x16</td>
<td>6,033</td>
</tr>
</tbody>
</table>

Air containers are normally closed containers and usually made of aluminum or fiberglass. They are not ventilated and thus there can be an increase in temperature, especially if they are left at high temperature. Some of these containers are cooled with dry ice or with refrigerated gels.

A very useful transport user’s guide for the Egyptian perishables was prepared by Essam (1998). This guide contains excellent information on land, but especially on air and marine transport routes, companies and schedules.
Modified and Controlled Atmospheres for Transport

Modified atmosphere (MA) and controlled atmospheres (CA) refer to systems that can either modify (MA) or control (CA) the atmosphere around the fruit. Common MA and CA systems for the maintenance of perishable crops contain lower oxygen and higher CO₂ concentrations than commonly found in the air. These systems can reduce metabolic activity, control some pathogens and insects, and thus prolong the postharvest life of the fruit.

MA and CA are not established yet for storage of mango, but are used for transport. Significant quantities of mango are transported in modified and controlled atmospheres. MA and CA should always be used as a complimentary treatment to an adequate handling system (especially the use of the adequate cold temperature), and should never be used as a substitute for that.

CA is much more effective than MA, but more expensive. CA systems are those that maintain at least a constant temperature, oxygen and carbon dioxide concentration. Some CA systems can also maintain a constant low ethylene concentration. Mango fruit is fairly resistant to anaerobic conditions and therefore it can tolerate relatively extreme gas concentrations. Optimum oxygen and carbon dioxide concentrations are about 2-5 and 3-10%, respectively.

MA and CA systems should only be used when justified. They can be used when a trip is longer than 8 days, and/or when fruit is in a more advanced stage of maturity.

Atmospheres with very low levels of O₂ and/or very high levels of CO₂, especially at high temperatures, can control insects and are been developed as quarantine systems for mango.

The inadequate use of MA and CA (use of lower oxygen and/or higher CO₂ concentrations than tolerated by the fruit) can result in the loss of the fruit.
Refrigeration and Storage

Only very minor quantities of mango in Egypt are refrigerated. Mango fruit picked at the optimum stage, harvested and handled adequately, and maintained at the optimum temperature and relative humidity can be stored for up to 4-6 weeks (depending on cultivar). Unfortunately, due to picking of fruit that is over-mature, and sometimes over-ripe, and that lack of use of refrigeration, the postharvest life of the Egyptian mango is estimated at only a very few days.

Temperature is the most important factor affecting postharvest life and quality of fresh fruit. Low temperature is needed to reduce metabolic activity, delay ripening and senescence, water loss, disease and insect activity, and thus maintain postharvest life and quality.

However, mango, like almost all tropical fruits, is very sensitive to low temperature. Chilling injury in mango is manifested initially as a brown discoloration on the skin, often accompanied by pitting. In severe cases the skin coloration becomes more pronounced and then the flesh is also affected. Chilling injury can also cause uneven ripening, poor color and flavor, and the fruit becomes prone to decay. Generally, storage below 10°C causes chilling injury in all cultivars of mango, although the time required for the visible symptoms to appear is cultivar dependent. Chilling injury can be reversed if the length held at low temperature is not too long. Variations exist in the degree of susceptibility of the different cultivars to chilling injury. Ripe fruit usually can tolerate lower temperatures than less mature fruit. The best control of chilling injury is to avoid exposure to temperatures lower than optimum. Other measures include maintenance in modified/controlled atmospheres, and conditioning at higher temperatures (35-38°C) for a few hours before storage at low temperature. Optimum temperature depends on the variety of mango and stage of ripening, and ranges between 10 and 13°C. Less mature fruits (intended for storage or transport for distant markets, especially by sea) should not be maintained lower than 13°C. More mature fruits, especially those for transport by air, can be maintained at 10°C. Lower relative humidity will promote water loss, shriveling, uneven ripening and quality deterioration.

High temperature is used to ripen the fruit and to control insects and diseases. However, the exposure of mango to long periods of high temperature can cause fruit damage. Mango fruit usually remains green at temperatures of 28°C or higher and does not ripen at temperatures of 33°C or higher for prolonged periods.
Work is needed in Egypt to identify the ideal temperature for the various mango cultivars and to characterize their storage life. Abou-Aziz et al. (1975) stored mature green Pairi mango fruit at 0°C for 5, 10, 15 and 20 days, and at 5°C, 10°C, and 15°C for 20 days, and found that the magnitude of increase in total soluble solids in ripening fruits was affected by storage temperature. They also found that sugar content tended to increase with prolonged storage and was rapid at higher temperatures. Changes in sugar content in fruit which was held at 0°C had a similar pattern but to a less extent than in fruit held at non-injurious temperature. A positive correlation was also shown between temperature increase and acidity loss in these fruits.

Pairi fruit stored at 4°C and 7°C was reported to have less firmness loss, less decay, and longer postharvest life than fruit stored at 25°C (Serry, 1997). The author did not mention the extent of chilling injury at low temperatures, but reported that the increase in decay after 3 weeks in storage was less at 7°C than at 4°C (which might be due to chilling injury). It is probable that on this basis she recommended storage at 7°C over 4°C. Storage at 7°C might still be lower than the safe temperature, and should be investigated further before it is used commercially.

Desoukey et al. (1997) evaluated the postharvet life and quality of Mesk mangoes at 7°C, 13°C, and at room temperature. Fruits stored at room temperature had more decay, more pulp softening, and longer postharvest life. Fruits stored at 7°C were reported to be firmer, of better quality and had less decay and weight loss than fruits stored at 13°C. There were no reports of chilling injury at 7°C, most probably because stored fruit were ripe.

Postharvest life of mango can be classified in three types:

1. Storage or transport life. The period from harvest to arrival to market, where the fruit should remain less ripe and resist physical damage, insect and disease attack.

2. Ripening period. The period between harvest until the fruit attains maximum consumer acceptability. This period includes the storage or transport period and the final stages of ripening of the fruit.

3. Shelf life. This period starts when the fruit is fully ripe and remains in an edible condition.
The packinghouse should include a cold storage room or rooms, depending on the capacity and the quantity of fruits packed. Mango is not commonly stored for prolonged periods. However, after pre-cooling the fruit should be moved immediately to the cold room or to the transport container. It is common (if fruit quantity is not sufficient to fill a transport container, or the container is not ready) for fruit to be held in the cold storage. Mangoes also need to be maintained in a cold storage room at the importing end before arrangements for marketing are finalized. It is important that the cold chain should not be interrupted (fast precooling, prompt placing in cold room or cold transport container, no exposure to high temperature). Fruit should be picked, packed, precooled and placed in the cold storage or cold transport container within no more than 24 hours. The cold storage room should be set at 12-14°C and a 85-90% relative humidity, should be equipped with adequate systems of air circulation, air exchange, and should be clean. Fruit should be stacked in a way that can permit adequate circulation of cold air. Air circulation should be enough to establish a uniform distribution of temperature and gases in the room.
Mixed Loads

Mango fruit can be stored or transported in a mixed load with other fruits. However, in order that no losses result to any of the mixed load, certain precautions must be taken.

1. Temperature and relative humidity. Mango should be stored or transported with crops with a compatible requirement for temperature (12-14°C) and relative humidity (85-90%).

2. Production of and sensitivity to ethylene. Mango should not be transported or stored with crops that produce very high amounts of ethylene, or products that are very sensitive to ethylene.

3. Modified and controlled atmosphere. When CA or MA is used for mango transport, mixing with other products is not recommended. This is due to the fact that different fruits (and even different cultivars of the same fruit) have different MA/CA requirements.
Local Marketing

It is very common that mango fruit in Egypt is sold on the tree to intermediary marketing agents. This practice is probably an important reason behind the deteriorated condition of some of the orchards. This practice does not allow the establishment of a fixed and consistent orchard management program. It is important that all handling practices in the orchard be practiced or managed by the owner(s). This is the most appropriate way to establish a consistent management program.

Almost all the fruit marketed (either wholesale or retail) in the country is maintained at ambient temperature. During early August, the temperature at the 6 October wholesale market was 38°C and the relative humidity 17%. These conditions can be very harmful to the fruit as they increase deterioration and losses.

The use of refrigeration is very scarce in the local markets. Refrigerated rooms are essential, especially in the wholesale markets, to reduce fruit deterioration and losses.

Fig. 38 Fruits in the local market are usually exposed to severe conditions of high temperature and low relative humidity.
Export

Background

Only few years ago, mango fruit was classified as an “exotic fruit” in the international market. Now, the fruit can be found in almost every world market, and this term is hardly ever used for mango anymore.

Mango fruit is considered to be the best paid tropical fruit for export. Although mango quantities in the world market are substantial big (almost 20 million tons), per-capita consumption, especially in export markets, is still very low (less than 1 kg annually). It is certainly clear that there are still plenty of opportunities to produce and export more and good quality mangoes.

Exported cultivars are mainly Keitt, Kent, Haden and Tommy Atkins. However, other cultivars are exported in minor quantities.

The Major Importing Markets

North America (USA and Canada)

This market is dominated by Mexico and Central and South America. It is a difficult market for Egypt at this stage because of the distance and strong competition by closer producers such as Mexico, and Caribbean and South American countries, and therefore it should not be considered a priority. However, it should be investigated for the future.

Mango exports to the USA in 1997 were about 201,190 tons, with a value of about 194 million dollars. In 1996, Mexican mangoes exported to the USA totalled 173,025 tons (86% of USA mango imports), with a value of 166.4 million dollars. Mexico export to the USA market is between the months of February to September, with a peak between May to July. Guatemala, Ecuador and Brazil are other minor exporters of mango to the USA. The consumption of mango in the USA is still very low (510 g/person), which can still increase significantly. This consumption has increased about 10% each year since 1992.

Canada imported 19,000 tons in 1996, at a value of about 18 million dollars, which increased to 21,500 tons in 1997. Mexico contributes about 66% of the Canadian mango importation. Canada import 18% of its mango from the USA, which is most probably from Mexico, which makes the Mexican contribution about 84%. Mango in
the USA is produced in Florida and Hawaii. In both states, mango cultivation is declining due to inadequate environmental conditions. In 1993, Florida produced only 1,250 tons, and Hawaii produced only 29 tons in 1991. In the USA there are no official standards for mango. The common varieties in the market are Tommy Atkins, Kent, Francis/Francine (from Haiti), Keitt, and Haden. Domestically produced mango is packed in boxes with a capacity of 35 lb. (almost 16 kg), while imported mango is packed in boxes with a capacity of 10-14 lbs. (4.5-6.0 kg).

**Asia (mainly Japan, Hong Kong and Singapore)**

This market is dominated by the Philippines, and will probably be targeted in the future by other Asian producers such as India. There is a strong interest by India to develop its export market and that will certainly alter some market trends. Small quantities of Mexican mango are exported to this market, with slight increases expected in the future.

The Japanese market is a specialty market that usually does not absorb large quantities. Japan imported in 1997 about 15,000 tons, mostly from the Philippines. Mexico exported 3,480 tons (23% of total imports) to this market.

Quality standards in the Japanese market are usually stiffer than in the other markets.

**Europe**

The European market for mango has been expanding significantly in the last few years due to the expanding ethnic groups and to the fact that phytosanitary regulations are less stiff than in the USA and Japanese markets.

Except for a very small quantity of mango produced in the southern part of Spain, there is no production at all of this fruit in any of the member states. Therefore, except for a very small quantity of fruit in the Spanish market, almost all the fruit marketed in Europe is imported. In 1994 total mango importation to this market was about 45,118 tons, with a value of about 53 million dollars. There seems to be a tendency for increased prices and imports. This market is dominated by several countries such as Mexico, Israel, Costa Rica, Colombia, Venezuela, Peru, Brazil, USA (Puerto Rico), Ivory Coast, South Africa, etc. Brazil is the biggest exporter of mango to Europe (12%). South Africa is estimated to have exported 1.5 million cartons of mango to Europe in 1998. Mexico, Pakistan, Israel, and Venezuela contribute about 7% each to the total mango importation to Europe. Mexico’s mango shipments to Europe have increased lately, reaching 1.47 million cartons in 1997,
slightly lower than the 1.66 million cartons exported in 1996, but well above the
699,546 cartons shipped in 1993. The main European export markets for Mexican
mango are Germany, France and the UK. There is strong interest by several countries
like India and Mexico to increase their share of this market.

This market is very important for the Egyptian mango, especially due to its closeness
and production period. Israel can compete with Egypt in terms of closeness, but
Egypt has the advantage in terms of labor, land extension, variable climatic
conditions, greater quantity produced, and longer production season. Mango in Egypt
is produced mostly (peak season) in August, September and October, which is late
compared to Mexico and relatively early compared to Brazil, which starts its exports
in late October.

Mango imports in Europe are highest between October and January, and dominated
by Brazil. The peak of the Brazilian export is in December. A second period,
characterized by small imports until March, is dominated by South Africa and Peru.
A third period, from May to September, is dominated by the USA, Mexico, and also
supplied by India, Pakistan, and Israel.

This market is expected to flourish for mango due to improvements in transport (the
use of marine transport), and other technologies that can maintain the fruit at high
quality (such as the use of CA) for a longer period.

Table 7 Import shares for mango (%) by some EC countries in 1993.

<table>
<thead>
<tr>
<th>Country</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Netherlands</td>
<td>32%</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>22%</td>
</tr>
<tr>
<td>France</td>
<td>18%</td>
</tr>
<tr>
<td>Germany</td>
<td>18%</td>
</tr>
<tr>
<td>Portugal</td>
<td>4%</td>
</tr>
<tr>
<td>Others</td>
<td>6%</td>
</tr>
</tbody>
</table>

Dutch imports of mango were 17,000 tons in 1993. They increased 140% from 1989
to 1993. A significant amount of mango received in the Netherlands is re-exported to
other EC countries. The most important suppliers to his market are Brazil, USA,
South Africa, Peru, Mexico, and Israel.

The United Kingdom has the highest per capita consumption of mango in Europe.
UK imports increased by 24% (3000 tons) from 1989 to 1993. Major suppliers to this
market include Pakistan, Brazil, Venezuela, USA, India, and Israel.
Total imports of mango to the UK in the 1997 were 15,878 tons, at a value of 14,097,000 pounds.

Table 8 Exporters to the UK market in 1997.

<table>
<thead>
<tr>
<th>Country</th>
<th>Tons</th>
<th>% of market</th>
<th>Value (1000 £)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>2,094</td>
<td>13.2</td>
<td>1,569</td>
</tr>
<tr>
<td>India</td>
<td>929</td>
<td>5.9</td>
<td>1,084</td>
</tr>
<tr>
<td>Jamaica</td>
<td>482</td>
<td>3.0</td>
<td>433</td>
</tr>
<tr>
<td>Pakistan</td>
<td>2,291</td>
<td>14.4</td>
<td>1,182</td>
</tr>
<tr>
<td>Puerto Rico</td>
<td>22</td>
<td>0.1</td>
<td>21</td>
</tr>
<tr>
<td>USA</td>
<td>216</td>
<td>1.4</td>
<td>204</td>
</tr>
<tr>
<td>Venezuela</td>
<td>1,482</td>
<td>9.3</td>
<td>1,401</td>
</tr>
<tr>
<td>Rest of World</td>
<td>8,362</td>
<td>52.7</td>
<td>8,203</td>
</tr>
</tbody>
</table>

French mango imports increased by 26% from of 1989 to 1993. Some of the mango imported by France are also re-exported to other EC countries. Mango suppliers to the French market include Burkina Faso, Israel, Ivory Coast, Mali, Mexico, and Peru.

German direct imports increased by 39% from 1989 to 1993. They increased from less than 2,000 tons in 1985 to more than 8,000 tons in 1991. This is very significant when considering that this fruit was virtually unknown at the beginning of 1980s. There are indications that this trend will continue in the coming years. Major suppliers of the German market include Brazil, South Africa, and the USA.

Other European markets should be investigated, and small promotinal shipments should be made. This should be organized through a well-planned program that can be best followed through HEIA. Other markets that should be investigated include Belgium, Greece, Spain, Italy, Portugal, Scandinavia, Switzerland, and some Eastern European countries.

Arabic market

This market is not very developed. Some Egyptian mango shipments are made to the Arab Gulf states, and a few, infrequent, and small shipments are made to Libya.

This market has excellent prospects for growth for Egyptian mango. With the exception of Sudan, there is no mango production in any of the Arab states. Therefore, all the fruit in this market is imported. The closeness of this market, the popularity of the Egyptian culture in almost all of Arab society, the development of the open Arab market (and thus the facilities that can be obtained in these markets), are major advantages for Egyptian mango.
Consumption of mango is usually introduced through visitors from the Arab States to Egypt. Therefore, a well organized program should be established to promote more consumption of the fruit, to establish better logistics, and better handling (including transport) programs for export to these markets.

Organized shipments should be increased to the Libyan market. Other Arabic countries should be looked at, including Lebanon, Jordan and Syria.

A much more aggressive and organized promotional program should be established for the different Arab countries.

Some producers, especially from Asia (such as Pakistan) and Africa (Ivory Coast, Mali, Burkina Faso), and even others such as Mexico, are targeting some Arab markets, especially Saudi Arabia and the United Arab Emirates.
Prospects for Mango Export from Egypt

World production of mango is about 18 million tons annually, mostly produced by about 15 countries, with India being the biggest producer. Mexico is the biggest exporter of mango (almost 200,000 tons).

Several countries are promoting the increase of their exports. Central and South American producers such as Mexico, Brazil, Venezuela, and Peru are trying to allocate more fruit in the North American and European markets. Egypt can compete with these countries for the European market due to distance, transport costs, and season of production.

The major export market for the African countries (South Africa, Ivory Coast, Mali, Sudan, Benin, Burkina Faso) is the European market. Some of the characteristics of these producers, including variety and season of production, share similarities with the Egyptian mango. For example, Ivory Coast exports to Europe about 2.8 tons of the green cultivar Amelie. Successful trials of this cultivar were made as recently as 1997. Immigration from these countries to Europe, and relations of some of these countries with some of the European countries (as ex-colonies) might play a factor in the promotion of their fruit in this market. However, the Egyptian mango can compete due to the large quantities that can be offered, distance of market, logistics, and establishment of a better production and handling technology. Egypt starts with a tradition of export activity to the European market (with other products, including grapes and some vegetables), an experience that can only help in the export of mango.

Asian countries such as the Philippines are traditional exporters to other Asian countries (such as Japan, Hong Kong, Singapore). This market is small, not very developed, and distant from Egypt, and therefore it is not a priority for the Egyptian mango at this stage, but should be investigated for the future. However, the major potential export market of other Asian producers, such as India and Pakistan, is the European market. These producers do not export significant amounts yet, but intentions exist, especially in India, to increase the quantities of exported fruit. There are some similarities in varietal characteristics (green varieties) and methods of harvest and handling of fruit between these producers and Egypt. However, Egypt’s experience in exporting other products to Europe again gives an advantage.

Total production of mango in Egypt is expected to reach 850,000 tons in 2001, and local consumption is expected to reach 450,000 in the same year (ATUT, 1997). Therefore it is crucial that an a well developed export industry is established as soon
as possible to eliminate the tremendous potential losses that would result in a few years.

Harrison et al. (1994) developed a detailed market analysis to identify the most profitable market windows, and to estimate a profitable demand for Egypt during those periods.

On the basis of a calculated Egyptian break even price (EBEP), Harrison et al. (1994) determined the Egyptian market window. The EBEP was estimated by these researchers to be $1.5 per kilogram of mango. On the basis of the EBEP, and the average wholesale price for mango in some European markets, Harrison et al. (1994) determined that wholesale prices in the German market are below the EBEP in February, March and in August. Wholesale prices in the UK are highest in April and July and even though lowest in September and October, are well above the EBEP. The average wholesale price in the French market is low in May and June, but well above the EBEP during the mango season in Egypt (August-October).

**Fig. 39 Export grade Mabrouka mangoes. Uniformity should be improved in regards to size and stem length.**

The study made by Harrison et al. (1994) includes excellent information, and proves that there is a clear and profitable window for the Egyptian mango in several European markets, including Germany, the Netherlands, the UK, and France. This economic study does not include information on other markets, such as the Arabic
market, but I assume that Egyptian mango would probably find excellent and profitable venues in several of these markets.

However, for the Egyptian mango to compete with other producers and to be profitable in all these markets, especially in Europe, several of the problems still faced by this industry must be solved.

The Organization for Economic Cooperation and Development provides guidelines defining international marketing requirements. Minimum requirements for fruit intended for the international market are that it should be intact, firm, fresh in appearance, sound, clean, free from black stains and bruising, free from damage caused by low temperature, free from pests and pest damage, carefully picked at the stage that allows transport, handling, and continuation of the ripening process so as to arrive in a satisfactory condition at its destination. Class standards are defined as: extra, good quality (class I), and marketable (class II). Fruit sizes commonly defined are: A: 200-350g, B: 351-550g, and A: 551-800g. The maximum permissible differences allowed within each size groups are: 75, 100, and 125g, respectively.

Mango for export must comply with the requirements of consumers and with the quality standards of the importing market in terms of size, color, appearance, absence of defects, ripening stage, uniformity, absence of insects and diseases, phytoanitary regulations, etc. Uniformity of quality is an extremely important factor for export fruit.

The fruit must arrive at the market at an optimum ripening stage that will allow a reasonable shelf life for retail marketing.

Depending on the importing market, the mango may need to be subjected to a legal disinfestation treatment. The only insect disinfestation treatment that is accepted by most importing countries is the use of heat treatments. Only a few countries still accept fumigation treatments.

Import markets have established various sets of quality standards, which include:

3. Europe. UN/ECE standard FFV-45. Concerning the marketing and commercial quality control of mangoes.

4. Egyptian standards for export and for local market.

In general import markets require that mango at arrival have the following characteristics:

- Be physiologically mature.
- 30 to 50% development of color.
- In the case of red cultivars, a significant amount of red area developed on the fruit shoulder.
- Fruit is firm.
- A minimum of 10% sugar.
- Uniform shape.
- Free from diseases, insects, latex stains, soil burns, and mechanical injury.
- Of a specific size and weight.

Prices in import markets are usually set on the basis of:

- The presence of red color. Red varieties are usually more expensive than yellow varieties.
- Maturity stage. Over-mature fruits are less desirable.
- Uniformity. Fruits should be very uniform in size, weight and color.
- Absence of diseases and defects.
Problems Faced by the Egyptian Mango for Export

Although there is excellent potential for the Egyptian mango industry, both on the national and the international markets, several problems which create difficulties for this industry must be solved. These problems can only be solved through a well-organized plan that must be developed and executed by all the sectors involved (producers, exporters, government authorities, and researchers). The efforts that have been accomplished in the last few years by the different sectors, such as ATUT, RONCO, HEIA, Ministry of Agriculture and Land Reclamation, and some researchers at different universities and research institutes, are excellent and should be continued.

The mango sub-sector study (ATUT, 1997) created by the collective effort of all the interested sectors, is excellent, and explains very clearly the real problems of the mango industry in Egypt. The recommendations in this study should be effected, especially by extension specialists. In addition, this study should be followed-up at least every two years to analyze advances and to modify recommendations. It would be very beneficial if such a study were translated into Arabic so that more people, especially growers, kelala buyers, marketing agents, and technicians could understand the real problems and how to solve them.

Although improvement in fruit trees (especially mango) is usually very slow and hard to notice, it is clear that some benefits in the Egyptian mango industry in the last few years are obvious. Some of the most important include:

- The close collaboration noted between the different sectors.
- Some improved preharvest management operations are either being accomplished or are being planned, including rootstock selection, varietal selection, pruning and fertilization programs, etc.
- Attempts are being made to improve some postharvest handling operations, such as harvesting indices, harvesting, ripening, packaging, transport, etc.
- Several other aspects are been discussed in a very serious manner, including the establishment of a quality control system, improvement of the logistics for export, the need for better and economical alternative for transport, etc.

Some of the most important problems remaining to be solved in order for the mango export industry to be a reality include:
1. Consumer misconceptions. These misconceptions include the relationship between latex and freshness, disadvantage of fibers, and the idea that fruit should be over-ripe. These misconceptions, especially those that affect the consumer, will continue to restrict the development of the mango industry. An aggressive promotional program should be established (at markets, schools, radio, television, newspapers, etc) to educate the consumer to the disadvantages of latex exudates (including causing allergies), the importance of fibers for human health, the problem of vitamin and fiber loss in over-ripe fruits, the economical losses in harvesting and marketing over-ripe fruit, etc.

2. Types of cultivar. Green or poorly colored varieties, which are preferred by the Egyptian consumers and some other ethnic consumers in Europe, will not be easily introduced in major quantities to important export markets. Some of the solutions to this include:

- **Sort-term**: Introduction of colored cultivars that are acceptable in export markets. A few of the new plantations in Egypt already include some of these cultivars.
- **Medium-term**: A promotional program should be established to introduce Egyptian cultivars to more consumers, especially in the European market. These studies can be done in collaboration with other African and Asian countries that produce and export similar cultivars.
- **Long-term**: Selection of better-colored varieties from the excellent genetic resources available in Egypt. It is very important to take advantage of some of the excellent characteristics of these varieties such as organoleptic characteristics and adaptation to local conditions.

3. Yield (average of 4.8 tons/feddan) and total production are low compared to other producing countries. But more importantly, export quality is fairly low. This low quality is mainly due to methods of harvest and postharvest handling techniques. Therefore, preharvest handling, including rootstock and cultivar selection, cultivation methods, tree size, pruning techniques, fertilization programs, insects and disease control, should be improved to increase yield. For export it is very important to have a sufficient supply of high quality fruit.

4. Postharvest handling methods and facilities: Harvesting indices, harvesting methods, precooling and refrigeration facilities, adequate packing systems and packing infrastructure, adequate packaging materials and systems, decay and insect control treatments, and transport, are still of inferior quality. They MUST be investigated and improved.
5. Not enough pre-cooling and cooling facilities and cold transport containers are used. These facilities are essential for local markets, and even more essential for export.

6. Facilities and logistics for refrigerated transport both by road and by sea are insufficient.

7. Lack of a “Total Quality Control System” and a “Certification Program for Quality”. Appropriate systems should be developed for both local and export markets.

8. The establishment of an organized and reliable logistics network is needed.

9. A strong and well organized promotional program should be initiated for the different potential export markets.

The recent experience of the mango exporters from Ivory Coast who introduced green mango cultivars to Europe can be taken as an example. An information campaign was launched using stickers in French, German and English. This was shown to be an ideal vehicle as it is cost effective, and is seen by 100% of the
consumers. One of the four different stickers is placed on the fruit and at least one of each is placed on the carton. One of the stickers bears the slogan “Green but ripe”, informing the consumers that green color does not mean that the fruit is unripe. Another sticker provides information on the fruit’s nutritional benefits, a third sticker informs the consumers how to cut up the fruit, and the last sticker informs them of the best way to store the fruit.

Pakistan is the major exporter of green-skinned cultivars to Europe.

Egypt should study the experience of these exporters of green cultivars, and should consider it when organizing a marketing campaign, and even consider the possibility of collaborating with these exporters in the same promotional program.

10. More research, especially in a collaborative way between the productive sector and researchers at universities and research institutes, should be undertaken. More support from the productive sector and the government should be made available for this research activity.
Processing of Mango

Processed mango, especially in the form of juice, is popular in Egypt. There are 12 processing companies in the country involved in processing mango juice. However, the quantity of processed mangoes is still very low (about 8,000 tons). Processing companies include Kaha, Foodico, Dolce, Juhaina, Aga, Best Midi, Naga, Edfin. Cultivars that are commonly processed include Baladi, Zebda, and Taymour.

The excellent internal quality (flavor, flesh color) of the Egyptian mango makes it an excellent material for the different processing derivatives (pulp elaboration, juices, fresh cut or minimal processing). These products can be used either for the local market or for export. In addition, this can solve the problem of the difficulty of exporting green cultivars.

The use of aseptic packaging for pulp should be promoted instead of freezing, as it better maintains the quality of the product.

Fresh cut or minimally processed mango should be tried, especially for the export market. This also would reduce the problem of the inadequate external appearance of some Egyptian cultivars for export.
Recommendations for Future Evaluation

Field evaluation of postharvest mango handling should be continued for several years to come. Here is a suggested program for such evaluation:

1. Select one average orchard in each of the different mango growing regions (El-Giza, Ismailia, El-Sharkia, El-Fayoum, El-Nobaria, etc). This orchard should contain the dominant cultivars in the region. In addition, the owners of the orchards should be willing to change and improve cultural practices and postharvest handling techniques.

2. Select some marketing agents (kelala), preferably one in each region, who are willing to modify and improve their handling practices.

3. Select one or two marketing agents in each of the important wholesale markets (6 October and El-Obour in Cairo and other important markets in other cities such as Alexandria) who are willing to improve the postharvest handling practices used.

4. Select three exporters that are willing to cooperate in the improvement of their exported fruit. It is preferable that these exporters be selected on the basis of their activity and the different markets to which they export.

This whole program of continuous evaluation (it should last for at least five years) at all levels and in all regions must be coordinated among all participants.

The objectives of the program should be to:

- Establish of the most efficient preharvest and postharvest handling system.
- Improve yield.
- Improve fruit quality.
- Improve logistics for export.

These orchards and the different marketing channels should be used as extension models to demonstrate the appropriate handling of the fruit.

A “mango day” should be established on a fixed date once a year, to show improvements, present seminars covering important topics, evaluate results, suggested modifications, new knowledge and technologies, and evaluate growers for the prize of the “Mango Grower of the Year”. This for sure will increase knowledge among growers, increase healthy competition, bring growers close together with
technicians, commercial agents, and authorities, and therefore will contribute to the improvement of the industry. In addition to the prize of the “Mango Grower of the Year”, it would be an excellent idea to establish prizes for “the best kelala agent of the year” and “the best marketing agent (tager) of the year”.
Recommendations for Research on Postharvest Handling

In Egypt, there are many excellent qualified research scientists who are very capable of implementing a well-executed research program. However, there seems to be a gap between the activity of the industry and the postharvest research and researchers.

There are strong need and strong interest by all sectors to improve the industry.

Some of the research needs related to the improvement of the postharvest handling of mango in Egypt are discussed below.

Short- to Medium-term

1. Maturity and harvesting indices. So far there are no established maturity or harvesting indices for neither of the mango cultivars growing in Egypt. A research program should be set for about five years to establish such indices for the various cultivars in the different regions.

2. Optimum transport and storage conditions (optimum temperature and length of postharvest life) for the various cultivars should be established. Growers and exporters are still not familiar with the ideal temperatures for the maintenance of most of the cultivars. In addition, it is thought that Egyptian mango cultivars are characterized by a short postharvest life. The postharvest life and storage capacity of all promising cultivars should be investigated. This program can be established and executed in about three years.

3. Development of treatments for postharvest decay control. Mango growing regions and seasons in Egypt are characterized by high temperature and relatively high humidity (in some regions), and so a significant number of fungal decay problems are encountered and must be controlled both pre- and postharvest.

4. Development of treatments for postharvest insect control. Several insects, especially the Mideterrenean fruit fly, infest the mango fruit and should be controlled both pre- and postharvest.

5. Preharvest factors effect postharvest quality. Several preharvest factors should be investigated, such as fertilization (including nitrogen and microelement content).

6. Ripening potential for Egyptian cultivars. The potential benefits for the establishment of an adequate ripening (off the tree) program, the ideal ripening
conditions for cultivars that can be ripened, and the potential advantages of ripening should be investigated for the leading Egyptian cultivars.

7. Product development and promotional strategies should be done for green cultivars in external markets, particularly Europe. This program should be done in collaboration with the European private and research sectors.

8. Major efforts should be invested in the local market to change (or at least to influence) the consumer habits in Egypt and try to change the conceived “mango quality” definition. It is extremely important to help change the handling of the fruit from the field to the market and to eliminate some of the problems that occur because they are becoming common consumer habit. For example, education of consumers should be directed to showing the disadvantages of latex, importance of fiber in the fruit, the lack of need for excessive sugar content, the effect of over-ripening on vitamin and fiber losses, etc. In addition, these efforts should show the consumer the possible economic losses that result from these habits, as for example the losses generated due to harvesting the over-mature fruit. These efforts should be organized through the mango council, and should be planned and executed by consumer specialists, food scientists, horticulturists, and social workers.

**Long-term**

1. Fruit color metabolism and manipulation. Research can be very helpful in understanding the color metabolism, especially in green cultivars, and the reason behind the ripening of these green fruits. This could lead to the manipulation and improvement of their color.

2. Breeding, especially the use of genetic engineering, is a long-term research tool that should be used for the development of cultivars that can incorporate the positive characteristics of Egyptian cultivars, such as adaptability and flavor, and can manipulate and improve some characteristics, such as a color.
Suggestion of a Text for the Establishment of
Egyptian Mango Quality Standards

Background

A large quantity of mango fruit is sold on the international market (almost 20 million tons). This quantity will increase steadily as different countries improve their industry, increase yield, and try to increase their presence in the export market. Mango is among the highest priced-fruits on the international market.

Competition is expected to grow more stiffer in the coming years. In addition, demand for higher quality fruit is increasing. Therefore, the most important prerequisite for a successful, profitable, and long-term exporter/importer relationship is a constant supply of top-quality fruit.

Fruit quality is the most important factor determining competition. In order for a product to compete adequately, especially in the export market, highest quality should be the aim.

Quality is a difficult term to be defined, and depends quite often on the type of product and its availability, cultivar, type of consumer (cultural influence), etc.

However, several factors are considered to constitute the quality components of a fruit such as mango. They include fruit cleanliness, size, color, degree of ripeness, uniformity (ripeness, color, size), absence of defects (debris, organic materials, bruises, blemishes, decay, insects), absence of certain residues, etc. Other characteristics also influence quality and are usually included when quality standards are established. These include package material (in some standards), package size, printed information on package, etc. All standards usually allow for some defect tolerances.

Some quality standards for mango have been established, among them:

- International standards.
- Mexican standards.
- European standards.
- Egyptian standards for export and for local market.
None of these standards are obligatory, however, they should be used by producers and exporters as a basis for quality control. These standards cover only fresh mango fruit and do not deal with mango for processing. All these standards are somewhat similar.
Suggested Text for: “Egyptian Standards for Mango”

Background

Egypt has separate standards for local and export markets. The standards for the local market were established in 1989. The export standards available were established in 1978. These standards restrict export to only 12 varieties (with low fiber content) including: Hindi bisennara, Hindi khassa, Mabrouka, Owes, Kalb eltor, Taymour, Company, Dabsha, Misk, Golik, Aromansy, and Ceylan 48. They also permit the export of Pairy mangoes to countries where shipping is less than 5 days by either air or sea.

The suggested modification and the establishment of the standards must be worked out by every organization or association, public and private, that is involved in mango production and handling, either for the national or the international market. Suggested modifications include:

1. Only one set of standards for mango should be used, and separated for local and export markets.
2. Standards should be developed for all, and not only for specific cultivars.
3. Standards for export markets should be compatible with the needs of the markets, and with international standards.
4. Include pictures that show characteristics of varieties, acceptable quality characteristics, defects and their tolerance, etc.
5. Standards should be made public and known to users in the private and the public sectors, including producers, marketing agents, exporters, technicians, etc.

After the text is agreed upon by all sectors, it should be published for a certain period (at least 3 months), so that it can be reviewed and criticized/modified by the interested parties, after which these standards can be made official.

Suggestions of organizations that should participate in the development of the standards, more can be added as warranted:

- Ministry of Agriculture and Land Reclamation. Several offices should participate, including the horticulture department, tropical horticulture department (Agricultural Research Institute), standardization department (if it exists), legal department, etc.
Secretary of Commerce. All departments related to standards, national commerce for perishables, international commerce, etc.

Growers associations, HEIA, mango council, etc.

Local marketing associations.

Export associations.

Researchers working on mango in universities and research institutes.

Consumer associations (if they exist).

It is recommended that only one set of standards (for both local and export market) be established. This will certainly increase the standard of quality in general. Although standards might be much stricter when applied to fruit for the local market, they should not be duplicated by different standards just for local market. Fruit in the local market is of lower quality, and therefore standards should be aimed for the improvement of the quality and not the opposite.

This text should be in Arabic.

Proposed Text

Definitions

I. Product

This standard applies to mango fruit of commercial cultivars (varieties) grown from *Mangifera indica* L. to be consumed fresh. Mango fruit for processing is excluded from this standard.

Defects

Minor defects: Those that do not affect in any considerable way the acceptance of the fruit by the consumer, nor its quality or shelf life. They may include very minor cracks, or minor sun burns or other minor defects that are very superficial with minor extension.

Major defects: Those that are not serious, but reduce considerably the acceptance of the fruit by the consumer. These include insect injury, minor decay attack, very minor cuts, shriveling, and some other defects that do not affect the flesh of the fruit.

Serious defects: Those that affect the pulp of the fruit and can cause the rejection of the fruit by the consumer. They include cuts, major insect and decay injuries, and other defects that affect the fruit pulp.
II. Provisions Concerning Quality

The purpose of this standard is to define quality requirements for mango for both the local and export markets.

**Minimum requirements**

In all classes, subject to the provisions for each class and the tolerance allowed, the mangoes must be:

- Intact and not having any mutilation or injury spoiling the integrity of the fruit.
- Firm, not exclusively soft and yielding to a reasonable finger pressure.
- Fresh in appearance. Skin not dull or showing signs of dehydration or shriveling.
- Sound. Produce affected by decay organisms such as to make it unfit for human consumption is excluded.
- Clean. Fruit should be free from foreign matter.
- Free from black stains or trails which extend under the skin.
- Free from marked bruising.
- Free from damage caused by low temperature.
- Practically free from pests, and damage caused by pests.
- Free from damage caused by low temperature.
- Free from abnormal smell and/or taste.
- Mangoes must be sufficiently developed, and display satisfactory ripeness.
- Fruit must have the characteristic form, flavor, and aroma of the cultivar.
- Mangoes must be picked carefully at the appropriate stage, so as to:
  - Permit continuation of the ripening process until they reach the appropriate degree of ripeness corresponding to the characteristic of the cultivar.
  - Withstand transport and handling,
  - Arrive in satisfactory condition at destination.
- Fruit should contain a pedicel of no more than 2 cm, but no less than 0.5 cm.

**Classification**

Mangoes are classified in three classes in a descending order as follows: Egypt Extra, Egypt I and Egypt II.
Fruit that cannot be classified in one of these three quality classes should be termed “Not Classified”, and should not be considered for any quality class in this standard. Mango fruit that does not meet the characteristics of the quality of “Egypt II” should be considered excluded from this standard.

The three classes are defined as follow:

**Egypt Extra**
Mango in this class must be of superior quality. Color and shape must be superior depending on the characteristic of variety.

Fruit must be free of defects, with the exception of very slight superficial defects provided that those do not affect the general appearance of the fruit, the quality, the keeping quality and presentation in the package.

Mangoes in this class cannot be derived from fruits collected from the ground, nor fruits ripened in the field by kamr, and should not contain latex exudates.

**Egypt I**
Mango fruit in this class must be of good quality. Shape and color must be characteristic of the variety. However, the following slight defects may be allowed provided that they do not affect the general appearance of the fruit, the quality, the keeping quality and presentation in the package:

- Slight defects in shape.
- Slight defects in skin due to rubbing or sunburn, suberized stains due to resin exudation and healed bruises not exceeding 3, 4, 5 cm² for size groups A, B, and C, respectively.
- Scattered rusty lenticels allowed.
- Yellowing in green varieties due to direct sunlight is allowed on up to 20% of the surface, excluding any necrotic stains.

**Egypt II**
This class includes mango fruits, which do not qualify to be included in the higher classes but satisfy the minimum requirements specified above.

The following defects may be allowed provided that the mangoes retain their essential characteristics with regard to quality, the keeping quality and presentation.

- Defects in shape.
Defects in skin due to rubbing or sunburn, suberized stains due to resin exudation and healed bruises not exceeding 5, 6, and 7 cm$^2$ for size groups A, B, and C, respectively.

Scattered rusty lenticels allowed.

Yellowing in green varieties due to direct sunlight is allowed on up to 40% of the surface, excluding any necrotic stains.

### III. Provisions Concerning Size

Size is determined by the weight of the fruit. The minimum weight of mango must be 200 g. Mango is classified into the size groups shown in the next table. Mangoes in the three quality standard classes can be present in any of the following sizing groups.

<table>
<thead>
<tr>
<th>Size</th>
<th>Average weight of fruit</th>
<th>Interval of size</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>209</td>
<td>200-218</td>
</tr>
<tr>
<td>B</td>
<td>236</td>
<td>219-259</td>
</tr>
<tr>
<td>C</td>
<td>283</td>
<td>260-317</td>
</tr>
<tr>
<td>D</td>
<td>352</td>
<td>318-369</td>
</tr>
<tr>
<td>E</td>
<td>386</td>
<td>370-461</td>
</tr>
<tr>
<td>F</td>
<td>536</td>
<td>462-541</td>
</tr>
<tr>
<td>G</td>
<td>546</td>
<td>542-578</td>
</tr>
<tr>
<td>H</td>
<td>611</td>
<td>579-669</td>
</tr>
<tr>
<td>I</td>
<td>727</td>
<td>670-740</td>
</tr>
</tbody>
</table>

### IV. Provisions Concerning Maturity

Mangoes should be harvested at the optimum stage and after full maturity. This can be best expressed on the basis of the flesh color. They should not be harvested before maturity stage 1, as indicated in the next table.

<table>
<thead>
<tr>
<th>Maturity stage</th>
<th>Yellow flesh color (percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Up to 25</td>
</tr>
<tr>
<td>2</td>
<td>From 26 to 50</td>
</tr>
<tr>
<td>3</td>
<td>From 51 to 75</td>
</tr>
<tr>
<td>4</td>
<td>From 76 to 100</td>
</tr>
</tbody>
</table>

Fruit for export must not be harvested over-ripe. It should not be picked later than stage 3.

### V. Provisions Concerning Tolerances

Tolerances with respect to quality and size shall be allowed in each package for produce not satisfying the requirements for the class indicated.
A. Quality tolerances

**Egypt Extra**

Five percent by number or weight of mangoes not satisfying the requirements of the class but meeting those of Egypt I or, exceptionally, coming within the tolerances of that class. These tolerances do not apply to decay and rotting, marked bruising and unhealed cuts.

**Egypt I**

Ten percent by number or weight of mangoes not satisfying the requirements of the class but meeting those of Egypt II or, exceptionally, coming within the tolerances of that class.

**Egypt II**

Ten percent by number or weight of mangoes satisfying neither the requirements of the class nor the minimum requirements, with the exception of fruit affected by rotting, marked bruising or any other deterioration rendering it unfit for consumption.

B. Size tolerances (in grams)

For all classes, 10% by number or weight of mangoes conforming to half of the permissible differences of the related size group above or below the range specified on the package, with a minimum of 200 g for those packed in the smallest size range and a maximum of 740 g for those in the largest size range, as shown in provision III.

C. Toxic residues tolerance

Mangoes should meet the Egyptian standards and the standards of the import countries concerning permitted residues and maximum concentrations permitted.

- Latex exudates: not permitted for class Egypt Extra or any class grade for export.
- Cuts: see indications of tolerances.
- Contact with soil: not permitted for export.
- Bruising: less than 5% for all fruit for export.
- Insect Injury: not permitted for export.
- Damage by low temperature: not permitted for export.
- Sunburn: 5% permitted in Egypt Extra and 10% permitted in Egypt I and II.
Rusty lenticels: 5% for Egypt Extra and 10% for Egypt I and II.

Fruit shriveling: 5% tolerances for Egypt Extra and 10% for each of Egypt I and Egypt II.

Decay (such as anthracnose, stem end rot, bacterial black spot, etc): Not allowed in any of the 3 class grades.

Heat injury, hot water scald: 5% tolerance for Egypt Extra, and 10% for Egypt I and Egypt II.

Over-ripeness: not permitted for export.

VI. Provisions Concerning Packaging and Presentation

A. Uniformity
Each package must be uniform and contain only mangoes of the same origin, variety, quality and size.

The visible part of the content of the package must be representative of the entire content in size, color and overall quality.

B. Packaging
Packages should be of an adequate size, material and design.

Mangoes must be packed in such a way as to protect the fruit properly.

The material used inside the package must be new, clean and of a quality such as to avoid causing any external or internal damage to the produce. Packaging must be free from all foreign materials.

The use of materials, particularly paper or stamps bearing trade specifications, is allowed provided that the printing or labeling has been done with non-toxic ink or glue.

The containers shall meet the quality, hygiene, ventilation and resistance characteristics to ensure suitable handling, shipping and preserving of the mango. Packages must be new.

Each package must bear the following particulars in letters grouped on the same side, legibly and indelibly marked, and visible from the outside:
Identification:
Name and address of producer, exporter, packer, or dispatcher.

Nature of produce:
- “Fresh mangoes”, if the contents are not visible from the outside.
- Name of variety.
- Size.
- Grade.
- Date of packing.

The name of the produce can be stated when the package is sealed and the content is not visible from the outside. However, the name of the variety is compulsory for all classes.

Origin of produce:
- Country of origin: “Product of Egypt”
- Optional: district where grown or national, region or local place name.

Commercial specification
- Class
- Size (reference letter or weight range)
- Number of fruit
- Net weight

Official control mark (optional)
Classification of defects

Insects
Minor: when the defective area is more than 3 cm and less than 5 cm.

Intermediate: when the defective area is more than 5 cm and less than 7 cm.

Serious: when the defected area is more than 7 cm and up to 9 cm.

Mechanical/physical injury defects
Intermediate: when the cut or defect covers an area of 1 to 3 cm, with a depth of no more than 0.15 cm.

Serious: when the cut or defect covers an area of 3 to 5 cm, with a depth of no more than 0.30 cm.

Sunburn
Minor: when it is present on the skin as a slight brown color that does not cause the skin to be firm.

Intermediate: when it presents in the skin as a brown color that causes the skin to be firmer, but it does not affect the flesh.

Serious: When it is present as a brown color in the skin and also affects the flesh.

Latex
Flow of latex
Minor: when the affected area is less than 10% of the total area of the fruit.

Intermediate: when the affected area is more than 10% but less than 20% of the total area of the fruit.

Serious: when the affected area is more than 20% of the total area of the fruit.

Latex burn
Minor: when the affected area is less than 2 cm².

Intermediate: when the affected area is more than 2 cm² and less than 4 cm².

Serious: when the affected area is more than 4 cm².
Specifications of defects in the three quality classes.

<table>
<thead>
<tr>
<th>Type of defect</th>
<th>Egypt Extra</th>
<th>Egypt I</th>
<th>Egypt II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor</td>
<td>Not permitted</td>
<td>Permitted</td>
<td></td>
</tr>
<tr>
<td>Major</td>
<td>Not permitted</td>
<td>Not permitted</td>
<td>Permitted</td>
</tr>
<tr>
<td>Serious</td>
<td>Not permitted</td>
<td>Not permitted</td>
<td>Not permitted</td>
</tr>
</tbody>
</table>

Hygiene

The product shall be free from any objectionable material. It is important to follow good manufacturing practices.

When tested by appropriate methods of sampling and examination, the product should be:

- ☐ Free from microorganisms in amounts which may represent a hazard to the health of consumer.
- ☐ Free from parasites which may represent a hazard to health.
- ☐ Free from any substances originating from microorganisms in amounts which may represent a hazard to health.

Pesticides

The fruit should comply with the maximum residue limits established in authorized standards for each market.

Heavy Metals

Mangoes shall be free from heavy metals in amounts which may represent a hazard to human health.
Quality Assurance for Mango

Recommendations for Mango Handling and Quality Control

Major efforts should be made to change consumer habits and educate the consumer. It is very important to establish a different definition of “mango quality” from the one currently understood by the consumer in Egypt.

Specific standards and regulations are usually set by import countries, and are mostly set by the importer himself. However, the general requirements for mango quality are set by different countries such as Mexico, UK, regions such as the European community, and lately by the Codex Alimentarius. The general requirements in most standards are similar. In each case the exporter should look very closely at the standards and regulations of the importer country and those of the importer himself.

General: All standards are set for mango of Mangifera indica L. In all grade classes and subject to the special provision of each class and the tolerance allowed, the fruit must be: intact, firm, fresh in appearance, sound (free of rotting and deterioration), clean (particularly free from any visible foreign matter), free from black stain or trails which extend under the skin, free from marked bruising, practically free from pests and practically free from damage caused by pests, free from damage caused by low temperature, free of abnormal external moisture, free of any foreign smell and/or taste.

Pre-harvest care: Fruit must be sufficiently developed and display satisfactory ripeness, and must be carefully picked at the stage of physiological development so as to ensure a continuation of the ripening process until fruit can reach the appropriate degree of ripeness, corresponding to the cultivar characteristics, to withstand transport and handling, and to be received at destination in satisfactory condition.

Maturity: Adequate harvesting indices should be established. Fruit should be harvested at the proper stage of ripeness. Mango for export should be harvested at or slightly after physiological maturity. This stage should be established for each variety and can be measured on the basis of shoulder development, skin color, and pulp color.

Picking should be done manually. Fruit should never be pulled from the tree, or left to be dropped on the ground. Fruit should be harvested and left with part of petiole
(about 3-5 cm) remaining in order to reduce the flow of latex. Fruit should be accumulated in plastic (not the classical wooden boxes used in Egypt) with different capacities of 10-20 kg. These boxes should always be kept clean. After accumulation, fruit in boxes should be kept in the shade before transport to packinghouse.

Handling after harvest: Transport to the packinghouse should be done carefully to minimize fruit injury. Transporters should use better roads, car speed should be slow, and shock absorbers should be in good conditions. Fruit should be pre-cooled (using forced air cooling). Packed fruit should be clean, of uniform size and shape, and free from defects.

Size: Depending on variety, fruit should be of very uniform size.

Color: Varies according to variety, but should be uniform.

Defects: Fruit should be free from defects.

Packaging: Fruit should be packed only in one layer in corrugated cartons. Most importers require boxes with 4 to 6 kg capacity (depending on importer specifications).

Labeling: Packages should bear: identity of product (mango), name of variety, country of origin, grade of the product, net weight, number of fruits, name and address of exporter/importer.

Cooling: Fruit should always be kept at optimum low temperature and relative humidity. Temperature is dependent on variety but ranges between 10-13°C. At this temperature mango fruit of most varieties, which is harvested at the right stage and handled carefully before and after harvest, can be kept for at least 4-6 weeks.

Transport: Transport containers should be clean and pre-cooled. It is very important that stacking should be done in a way that never blocks cold air, nor permits warming of the fruit. If a mixed load is to be used, other fruit selected should be compatible with mango.

Other treatments: Controlled atmosphere can be used for sea shipments to distant markets more than eight away.
Establishment of a Certification Program for the Quality of the Egyptian Mango

Due to market competition it is essential to develop a quality control system following the standards established by the International Standardization Office (ISO). However, it is better that quality certification be developed on the basis of the developed Egyptian quality standards.

The establishment of a certification program is crucially to building an image for the Egyptian mango and confidence in the fruit by the importer.

Due to the fact that the term "quality" is very ambiguous and difficult to define, it is important to first establish a "certification system" that can be developed and agreed upon by an association of producers and exporters. This system should include the following:

1. Maturity indices should be developed and a harvesting system should be established.
2. Each packer/producer/exporter should make sure that maturity indices and harvest techniques used in his establishment be the ideal.
3. A "seal of quality" should be established, indicating the certification of the fruit.
4. A certification system for fresh fruit should be developed by producers/exporters, and a "quality manual" should be developed for this purpose.
5. A certification team (technicians) should be trained and used to establish the system. This "quality assurance team" will be the responsible agent to certificate the fruit received in the packinghouse/market, confirm its grade, and whether it is adequate for export or not.
6. Not all fruit will pass through the system, not all producers and probably not all exporters will be part of this system. However the "seal of quality" should be the factor that distinguishes between "certified" and "not-certified" fruits. Producers/exporters associated with the system should be the only ones who receive the service of certification, and thus the "seal of quality". Mango with the "seal of quality" should be promoted and distinguished.
7. The "seal of quality" should be awarded when:
   - The quality control is done by an inspector approved by the association, and the inspection follows the "quality manual".
An initial visit is made to the establishment to install the procedure of the quality control system.

Random visits should be made to the establishment to monitor the process.

**A Suggested Working Plan for a Quality Control System**

A specific plan should be prepared for each market, and should include:

1. **Fruit must be screened in the field to insure export quality.** This operation can be done by the exporter or by agents working for the exporter association. This way exported fruit is assured to be in higher quality and suitable for the export market.

2. **Development of a registry for each shipment.** A detailed historical registry of fruit is needed that covers all aspects of the operation such as origin of fruit, date of harvest, date and hour of packing, and special treatments applied. This registry will help identify the cause of problems that appear during marketing.

3. **Inspection.** All packed fruit should be inspected (fruit and package) before leaving the packinghouse to assure its quality. It is important that all information should be printed adequately on the package. Fruit should be taken out of the package and inspected individually and its grade should be specified according to the set of standards. Some importing countries allow inspection at the exporting site. If quarantine systems are needed, official inspectors, through agreement between the import and export authorities, assure that phytosanitary regulations are adequately applied and fruit is strictly secured from re-infestation. Quality inspection can be done either at the export site, at the port of exit or at the port of entry.

4. **Specifications of export mango.** These are set according to the requirements and the standards of the importing country. Here are some general specifications for the markets in England, Europe, and Canada.
   - Varieties. The most popular varieties are Tommy Atkins, Haden, Keitt, and Kent. However this will depend on the importer.
   - Color. Skin color should be partly red with green and yellow. Pulp color should be yellow to orange.
   - Appearance. Size and ripening should be uniform. Fruit should be free of defects such as mechanical damage, decay, insect damage, etc.
Conditions. Fruit should not show latex staining, mechanical cuts, or insect and disease damage

Size. As an example, the sizes needed for Haden and Tommy Atkins are as follows:

<table>
<thead>
<tr>
<th></th>
<th>Haden</th>
<th>Tommy Atkins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum weight</td>
<td>300 g</td>
<td>350 g</td>
</tr>
<tr>
<td>Minimum longitude</td>
<td>9.0 cm</td>
<td>10 cm</td>
</tr>
<tr>
<td>Minimum width</td>
<td>8.0 cm</td>
<td>9.0 cm</td>
</tr>
<tr>
<td>Minimum thickness</td>
<td>8.0 cm</td>
<td>9.0 cm</td>
</tr>
</tbody>
</table>

This plan should be established as a written working plan that is followed by inspectors according to the established standard. After editing and finalization of this working plan by all members of the association, it can be used in a way that can establish uniformity in the evaluation of fruit quality.

The following matters have to be decided upon, and should accompany the established certification program.

Authority: It is important that a certain organization, for example the exporters association or the mango council, be designated the authority who regulates the use of this plan.

Fruit inspected: It is preferable that all fruit exported should be inspected. However, the other alternative can be that fruits, whether for export or for local market, can be inspected. Only those that pass the inspection process can be awarded the “seal of quality”. This seal of quality should be promoted to distinguish and to reward fruits, orchards, and operations that follow a strict quality control system.

Area of work: The certification of quality can be in any place where there is adequate infrastructure for inspection:

- The packinghouse.
- Receiving site at the port for fruit to be shipped by sea.
- Receiving site at the airport for fruit to be shipped by air.
- Receiving site at the border for fruit shipped by road to some external market.
- Receiving site at the local wholesale market or distribution center.
Logistics of initiation of service. Producer, marketing agent or exporter should request the service of the inspection, and should provide all the information needed by the inspectors.

Inspectors: These are qualified technicians (at least with B.Sc.) who are trained and certified.

Sampling and analysis: Sampling for inspection should be done on the basis of an established statistical method elaborated by the authorized organization, following an established format, and in the presence of the person who requested the service or his/her representative. Samples should be taken at random. Tables should be established for the inspector to define sample size.

**Suggested sample size**

<table>
<thead>
<tr>
<th>Units (such as packages)</th>
<th>Units to be selected at random for inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 100</td>
<td>5</td>
</tr>
<tr>
<td>101-300</td>
<td>7</td>
</tr>
<tr>
<td>301-500</td>
<td>9</td>
</tr>
<tr>
<td>501-1000</td>
<td>10</td>
</tr>
<tr>
<td>More than 1000</td>
<td>15</td>
</tr>
</tbody>
</table>

The sample taken should be inspected in such a way that does not destroy the fruit. In other words, this inspection should be taken as a confirmatory inspection, and no destructive means should be used in the evaluation.

If the shipment is made of more than one type of mango all types should be inspected and registered separately.

Inspection should be done for fruit, package, labeling and printing, and total presentation.

Information needed for inspection: The request for the inspection service should include the following information:

- Name, address, telephone, etc. of person (name of company if applies) who requested the service.
- Type of mango (cultivar), quantity, grade (according to the established standard).
- Destiny of the fruit.

Results of inspection and reports: Inspected fruit that meets the standards for any of the three grade classes should be awarded the “Seal of Quality”. The seal of quality should identify the class of the fruit. Results should be written very clearly on the
official forms, which should be produced in sufficient quantities to distribute to all interested personnel requesting the service, the controlling body, the inspector office, etc). Report results, and whether the “seal of quality” is awarded or not, MUST be justified by supporting and sufficient data. The results, and the awarding or not of the “seal of quality” must be given immediately after inspection to the person who requested the service. The inspector can recommend changes, which, according to the standards, can change the results positively, and the “seal of quality” can be awarded after such a modification. The person who requested the service can decide whether to follow these recommendations or not.

Disagreements: All disagreements should be submitted in a formal manner to the body that controls the system. In addition, suggestions to solve or improve these problems should be included. These problems should be discussed so that the system can be improved year after year.

Evaluation of the system: Once a year (right after the termination of the mango season) this system should be evaluated by all users. The evaluation should take into account all comments, and all other information that can improve it. It is important that an independent organization or company be established to execute the certification program under the jurisdiction of “the mango association or council”, and this certification program should be compulsory for all members.
General Recommendations

Some general recommendations for optimum postharvest handling of mango in Egypt

It is very important that at the same time efforts are being made to introduce new improved cultivars, local varieties should be selected and improved to take advantage of their positive characteristics such as adaptation and excellent flavor.

Here are some of the characteristics of some of the cultivars that have been introduced in small quantities and are planned for further expansion.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Alteration</th>
<th>Fruit size</th>
<th>Fruit color</th>
<th>Fiber content</th>
<th>Susceptibility to anthracnose</th>
<th>Susceptibility to cold</th>
<th>Susceptibility to physiological disorders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haden</td>
<td>High</td>
<td>Medium</td>
<td>Red/yellow</td>
<td>Moderate</td>
<td>High</td>
<td>High</td>
<td>Strong</td>
</tr>
<tr>
<td>Keitt</td>
<td>Low</td>
<td>Large</td>
<td>Pink/yellow</td>
<td>Low</td>
<td>Very low</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Kent</td>
<td>Medium</td>
<td>Medium</td>
<td>Red/yellow</td>
<td>Very low</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Tommy Atkins</td>
<td>Low</td>
<td>Medium</td>
<td>Yellow/red</td>
<td>Moderate</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Van Dyke</td>
<td>Low</td>
<td>Small</td>
<td>Red/yellow</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

There is a strong need for a manual to be written in Arabic in clear terms, especially for growers, packers, and exporters. The manual should cover preharvest and postharvest, marketing information and strategies, logistics, and regulations for the production and export of Egyptian mango.

Since the Egyptian local market is accustomed to very aromatic mango varieties and seems to resist the acceptance of new varieties such as Keitt, Kent, Tommy Atkins, etc, I recommend the introduction and trials of varieties such as Manila and Ataulfo from Mexico. These varieties are characterized by a relatively strong flavor and will turn yellow when ripe, which makes them excellent candidates for both local Egyptian and export markets.

Grow only a few selected cultivars.

Grow different cultivars in separate blocks or at least in different lines. Do not mix different cultivars in the same line. In a commercial orchard never mix different cultivars on the same tree.

If mango cultivation is to be inter-planted with other crop, it has to be selected so it will not cause competition problems for mango (such as phytosanitary problems, shading, etc), and must be removed when mango fruit reaches the later development stages.
Apply an integrated preharvest program for fertilization, irrigation, diseases and insects control. Fertilizers should be applied at the right time (just after harvest).

Harvesting methods must be changed to reduce fruit injury. Fruit should be cut gently with scissors, collected in the harvesting package, and when filled this should be dumped very gently in a collection container.

![Image of baskets commonly used for collection.](image)

**Fig. 41 Baskets commonly used for collection.**

Shipment of mango for export by sea should be encouraged. Sea containers should be filled directly in the packinghouse. This would improve the competitive edge of the Egyptian crops. Sea transport from Egypt to Europe takes a long time (6 to 13 days, sea transport from Mexico to Europe takes about 14 days). The long period is due to inconsistency in arrival of ships and excessive stops. Efforts should be made to reduce the transport period. On the other hand, efforts should also be made to improve postharvest life of crops to enable them to be transported by sea.

Very few precooling and cold storage facilities are available and they are used mostly for grapes and vegetables. They should be increased and adopted for use with mango.

Quality control for other exported fruits and vegetables was fairly good at almost all operations visited. Total quality control, not just when fruit is intended for export, should be implemented and practiced.
Increase the production of high quality fruit, especially for export markets by improving cultural practices.

National programs for insect, especially fruit fly, control that involve all growers and government agencies should be implemented.

Develop adequate maturity indices for different cultivars from different regions. A research program should be initiated for this purpose.

Only mature fruit should be harvested. Do not leave fruit to ripen or over-ripen on the tree.

Fig. 42 Fruits are commonly picked and packed over mature, and packages are usually overfilled, which increases fruit deterioration and losses.

Never wait for fruit to be dropped so that it can be picked.
Fig. 43 Defects due to sun burn and dropping of fruit on the ground.

Never let fruit to drop on the ground. Do not pack fruit (especially for export) that is collected from the ground.

Picking should be done several times. If this is impractical, then it should be delayed until most of the fruit is nearly ripe (depending on the distance and type of market).

To reduce the problem of latex flow and staining, pick fruit in mid-morning and avoid picking immature fruits; cut fruit with a stem and do not pick right after rainfall.

Harvesting should be discontinued after mid-day, when temperature is high, to reduce field heat.

Pickers should be trained to pick the right fruits and to handle them properly, and should be supplied with the needed picking tools.

Scissors should always be used whenever possible for picking.

Higher fruit should not be picked by a hook (khattaf) without a net, as it results in dropping and damaging of fruit. A net should be added to the hook, and a means of cutting the fruit (rather than pulling it) should be installed at the end of the hook.
It is important that fruit not be mechanically injured at any stage. Pickers, packers, and others at different ends of the handling chain should be trained to handle fruit very carefully.

Picking net and tools should be designed to leave about 2 cm of stem and should not harm the fruit.

Collection boxes or baskets should not cause injury to the fruit and should not be overfilled. Use appropriate collection and field packages that do not injure the fruit and those that can use the space efficiently during transport and storage.

Fig. 44 Collection boxes used at one of the farms. Notice that they are not big in size and not over filled.

Picking and collection baskets and boxes should be clean.

Fruit should be kept in a shed in the field, should not be exposed to direct sun or high wind, and should not be kept for a long period in the field after harvest.

If fruit is packed in the field:

- It should not be left in contact with the ground.
- Packaging should be done on tables, and not on the ground.
- Packed fruit should be uniform in size and maturity.
Fig. 45 Fruit left in contact with the ground will gain heat and are easily infected with decay organisms.

Fruit should be transported as soon as possible to the packinghouse, cold store or market.

Do not let fruit spread on the ground, as is commonly done. Use tables to pack fruits, as that is much healthier and efficient for workers and causes less problems for mango.

Transport should be done in adequate vehicles, preferably cooled. If vehicles are not cooled, they should be covered to protect the fruit from direct sun, high temperature, and wind. Transport should be equipped with adequate shock absorbers to reduce mechanical damage. Transport should preferably be done during the cold hours of the day, and should follow the best available roads.
Fig. 46 Fruit is transported to a packinghouse to be graded and packed.

If transport vehicles are refrigerated they should be used properly. Vehicles should be clean, not damaged, with sufficient refrigeration capacity, and with efficient air circulation. The product should be stacked in a way that can permit ideal cold air circulation. The vehicle should be pre-cooled before stacking the product. It is recommended that the product be stacked on appropriately sized pallets (rather than handling boxes individually).

The packing line should be designed in a way that can be simple and does not cause injury to fruit. In addition, it should be designed to provide comfort for workers, especially with respect to light, temperature, height of packing tables, etc.

In the packinghouse, fruit should be received in water with chlorine and a permitted fungicide.

Pack only fruit of high quality. Do not pack injured or decayed fruit, especially for export.

After a pre-selection step, where inadequate fruits are removed, mango can be treated with hot water for disease control (50-55°C for 5-15 minutes). In this case, fruit should be cooled with water immediately after heat treatment.

Fruit can be size or weight graded. Weight graders are recommended because they result in better fruit uniformity.
Waxing is not commonly used in mango, but in case it is, one should use waxes of natural origin, which should be applied in a thin film to avoid fruit fermentation. Refer to the regulations of the importing country to see if waxing is permitted and the type of wax allowed.

Packaging should be done manually by trained persons. Each package should be printed with the required information indicating: origin of fruit, day of harvest, day of packing, and packer's name. This is very helpful to track any problem that can appear during the market.

Packages should be the right size (not very big), and should be designed to protect and promote the fruit.

Fig. 47 Some small packages used on one farm.

Packages should be designed and/or chosen to be efficient, with sufficient stacking force, sufficient vents, causing no injury to fruit, and be printed with the necessary, especially promotional information.
Ventilation design should be chosen on the basis of air circulation in the transport container (either vertical or horizontal).

Refer to the regulations of the importing country for type of packaging material allowed, type of information printed, size of package, size of pallet, etc.

Packinghouse should be kept clean and organized.

Cool fruit rapidly using forced-air cooling. The delay in cooling results in short shelf life. Exposure of fruit to high temperatures for 3-4 days after harvest causes substantial postharvest losses, resulting in premature and uneven ripening in several cultivars. Fruit should be pre-cooled to about 2°C above optimum temperature.

Maintain fruit at low temperature during storage and transport. Optimum storage temperature depends on the cultivar, but ranges between 10 and 13°C. It is important to define optimum temperature for each cultivar. Do not expose fruit to temperatures below optimum (usually below 10°C). Optimum relative humidity is 85 to 90%.

Fruit exported by sea for more than one week can be transported in modified or controlled atmosphere. CA is more expensive than MA. CA is not always justified, nor is it always beneficial. It should be used only when the transport period is long, or fruit is more mature than usual for exported fruit.


Export is more efficient when done through an organized export association.

Quality is the key to a successful industry, especially an export industry. Export markets are very competitive, and the only way to succeed is to implement a total quality control program.
References


