Application of Postharvest Technology in Mango

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ABSTRACT

The application of postharvest technology in mango has been addressed in developing technology to prevent and eradicate postharvest pest and diseases, to maintain as well as to improve quality and non-destructive techniques to evaluate quality. Technology in pest and disease treatment focuses on disinfestation against fruit flies using heat treatments, irradiation, quick freezing, fumigation and chemical treatments. Maintaining and improving quality are essential to prevent quality deterioration and increase added value of the product by applying technology during postharvest handling. This includes processing through development on material used, modification of micro environment and technique applied. Non-destructive technology that has been developed for mango in these recent years is Near Infra-Red (NIR), image processing, ultrasound method and X-ray.

Keywords: Postharvest technology, Mango, Pest and diseases, Non-destructive quality evaluation, Quality improvement.
INTRODUCTION

Mango is one of the popular products from Asia, including Indonesia which is very popular among others tropical fruits. Indonesia is the world's sixth highest producer of mangoes with 1,621,997 ton or 8.3 ton/ha in 2006 (Directorate General of Horticulture, 2008; BPS, 2011). During 1998–2006, total national production of mango increased with 2,243,440 ton in 2006 (BPS, 2011). Export development also pointed out positive growth of 7.1% during 2002–2006 (Dewandari et al., 2009) which in 2006 was marked by 1.182 ton. The largest exports marketed were to United Arab Emirates, Saudi Arabia and Singapore (MoA, 2011). Among the many cultivars planted some of the exported mangoes are cv. Kensington (Australia); Irwin, Tommy Atkins and Keitt (Florida, USA), Nam Doc Mai (Thailand), Gedong Gincu, Arumanis and Golek (Indonesia). However, mango is a perishable fruit which needs appropriate postharvest handling in order to meet and to compete consumer and food standard.

Besides quick quality deterioration occurring in perishable fruits, the critical constraints in postharvest handling of mango are pest and disease attack which in turn fasten quality deterioration. It has become a challenge how to provide technology which enables to minimize deterioration, extend the shelf life by means of easily accessible technology for producers and safer in the perspective of environmental and food safety. More attention is then addressed for the development of non-destructive techniques to evaluate the quality of fruits and disinfection of fruit flies and fungus which associate with postharvest pest and diseases. In order to improve added value of mango due to its perishable characteristic into more stable form, some processing technology has been developed in juicy mango; dehydrated products such as crackers and vacuum-puffed mango; spray-dried mango.

POSTHARVEST TECHNOLOGY FOR PESTS AND DISEASE TREATMENTS

The most serious postharvest diseases that are considered reducing economic value and becoming deterrent to mango exports to some countries are anthracnose and stem-end rot which are caused by fungus pest attack like fruit fly and seed weevil. At the onset damage symptoms caused by fruit fly and seed weevil are not visible as there is no external evidence of infestation. Regardless, those pests attack fruit when it is still attached on the tree, the presence of the damage will affect postharvest quality significantly as fungus and pests cause fruits' decay which hastens ripening.

Many researches in postharvest sector have been conducted to develop technology for preventing or eradicating their attack especially for fruit disinfection by applying vapor heat, hot air, hot water, irradiation, quick freezing, fumigation and chemical treatments (Johnson and Hofman, 2006). Heat treatment using vapor, air and water has been more popular since the restriction of methyl bromide as fumigants. This substance was considered
an environmental issue problem as an ozone-depleting chemical. In the USA, this substance was phased out completely in 2005 but some emergency uses for quarantine applications may be permitted, e.g. to destroy a serious quarantine pest in an imported consignment or to meet official requirements of an importing country (EPA, 2008 in Johnson and Hofman, 2006).

Vapor heat treatment (VHT) uses air heated by water vapor at temperature about 40–50°C to heat the fruit in which the air heating circulation can be performed using with or without forced air. The present development of VHT technology on mango has put in several necessary conditions on the application of length of exposure time, fruit waxing and combination with hot water treatment (HWT). HVT held at the fruit centre at 46.5°C for 20–30 min prior to bee waxing at concentration 6% could effectively kill B. dorsalis eggs infested in mango cv Gedong Gincu and could prolong the shelflife up to 28 days (Hasbullah et al., 2008). During the storage, fungus identified as Colletotrichum gloeosporioides and Pestalotiopsis mangiferae which cause anthracnose and stem end rot were found in non-HVT while it was not found in fruit exposed to VHT (Marlisa, 2007). Besides those two fungus, Lasiodiplodia theobromae and Cladosporium cladosporoides are two others fungus that infest in primary Indonesian mango cultivar, Gedong Gincu, during storage (Hasbullah, et al., 2008). Jacobi et al. (1997) found no diseases either anthracnose nor stem end-rot, in mango cv. Kensington treated with combination of HWT and HVT while untreated fruit experienced severe damage at 10.9% of skin area affected. In the development of heating media, it had been revealed that forced vapor-saturated-air and hot water transferred heat most efficiently to the fruit surface where thermal stress occurred the greatest during heating in vapor-saturated-air (Shellie et al., 2000).

During research development before 1999, Hallman (1999) stated that irradiation may be the most broadly applicable quarantine treatment against fruit flies. This could be driven from the performance treatments showed by 46.1°C water immersion quarantine treatment for mangoes ≤ 0.7 kg, which is sometimes detrimental to fruit quality and a treatment > 0.7 kg which cannot currently be treated with hot water due to lack of efficacy and commodity tolerance data for longer treatments. The application of irradiation for fresh fruit is in the range of 250–750 Gy. The range should incorporate the doses for individual pests and commodities due to susceptibility of each fruit.

Quick freezing is held by exposing mango to lower temperature (–17°C) and holding at –6°C or below for 48 h to disinfect mangoes for processing but it is not further approved for importing mangoes with seeds because mango weevil could be presented (Johnson and Hofman, 2006). Chemical treatment was used in examining effect of acidic solutions, hydrochloric acid (HCl), alone or in combination with prochloraz on the control of Alternaria alternata in mango which cause alternaria rot in mango.
(Prusky et al., 2006). It was found that application of hot water spraying a brushing for 15–20 s followed by spraying with 50 mM HCl alone combination with prochloraz at 45 to 900 mg/kg could effectively prevent *Alternaria* rot in stored mango. The enhanced prochloraz activity was attributed to its enhanced solubility which resulted in an increase in the fungicide active ingredient in the solution.

**TECHNOLOGY FOR QUALITY IMPROVEMENT**

Consumers judge fresh mango from its visual appearance e.g., color and size which in some cases determine maturity level, injury symptoms on skin surface which is closely related to mechanical damage and physiology as well as chilling injury (CI) indices. Flavor, aroma, and texture are other convincing market requirements which correlate with chemical compounds i.e., sugars, volatiles, and firm tissues. Consumers, in common, describe directly the quality of mango based on those four quality attributes. Beyond the diversity of cultivars, consumers sometimes only put their interest to several cultivars which have attractive flavor and aroma. Those attributes are closely related as the constituent of aromatic compound will result in different flavor and aroma. Firm tissues generally relate with softening which is sometimes undesirable as it is a sign for senescence or internal decay.

Many researches in postharvest have been conducted to identify and look for any necessary technology mainly in method on how to improve quality in extended shelf life either in fresh intact or minimally processed mango. For most fresh produce, shelf life is best defined as the period with which the product retains acceptable quality for sale to the processor or consumer (Aked, 2002). The researches have been addressed to methods and techniques in pre-cooling, packaging, ripening, sorting, grading, storage, and transportation using heat treatment, chemical treatment, modified atmosphere packaging (MAP), or combination. Identification pays more attention on applied technology effects to physicochemical properties of product.

**Pre-Cooling**

*Pre-cooling* can be in the form of water or hydro, air and ice as the cooling medium and also through application of forced circulation. The combination of water and ice medium for cooler could give better results in maintaining fruits quality (i.e., Solid Soluble Content (SSC), acid content, color and firmness which represents texture) rather than used alone applied in mango cv. *Cengkir Indramayu* (Nurmawati, 2008).

**Packaging**

Technology development in *packaging* of fresh mango largely carried out exploring material used while minimally processed is in development...
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micro environment such as modification of atmosphere (O₂ and CO₂) through means of coating on individual fruit. In the development of packaging material, wooden and plastic are being used commonly for domestic market while cartoon is objected for export purpose due to its practical easiness and technology advantages in maintaining fruits quality. In general, the required advantages of packaging i.e. increased shelf life, prevention from mechanical damage and hazardous microorganisms, maximize quality, alleviate CI and reduce weight loss.

Edible coating on fresh fruit can provide an alternative to modified atmosphere storage by reducing quality changes and quantity losses through modification and control of the internal atmosphere on the individual fruit (Park, 2002), reduce decay and improve appearance (Baldwin et al., 1999). In mango, different coating materials have different effects on fruit quality. Polysaccharides were found to have ability to provide increased concentrations of flavor volatiles while carnauba wax could significantly reduce water loss (Baldwin et al., 1999). Hoa et al. (2008) examined coating using Xedabio for mango cv. Cat Hoa loc under ambient storage conditions. It was found to be the best material as it retarded ripening by 3 days over other treatments.

Modified atmosphere (-5% CO₂ and -10% O₂) in 4-kg film-lined cartons using Xten® film (XF) for mango cvs. Tommy Atkins and Keitt at 12°C was found to be the most effective in reducing CI than using polyethylene (PE) (Pesis et al., 2000). Other advantage of using XF film was the reduction in the level of sap inside the package due to the lower relative humidity in the XF film (-90%) compared with that of PE packaging (-99%). The thickness also becomes the important parameter which significantly affects the visual appearance and consumers sensory perception (Rujiati, 1991). It was reported that besides the best predefined atmospheric concentration of O₂ and CO₂ at 2.5% and 5%, the thickness of PE at 0.02 and 0.04 mm is the best value for mango cvs. Arumanis and Indramayu modified atmosphere based on damage level on visual and physical, chemical and sensory acceptance, respectively. Statistically, the thickness of PE significantly influence towards weight loss, firmness, water content, vitamin C content, accumulation of CO₂ inside package and sensory acceptance while weight loss did not influence. Anaerobic respiration should be prevented in modified atmosphere packaging (MAP) by maintaining the composition of O₂ level inside package for not becoming too low (at least 2–3%). Too low O₂ level composition results in the development of pathogenic bacteria Clostridium botulinum and accumulation of ethanol, acetaldehyde and organic acids cause unwanted smell which indicates the deterioration of the quality.

Packaging material for transportation purpose generally uses wooden crate, corrugated cardboard and additional material for filler. But now, use of wooden crates for packaging is being restricted in international markets on account of quarantine concerns and special disinfestation treatments
necessary for international trade (FAO, 2002 in Anwar et al., 2008). As a result, corrugated cardboard now becomes the largest alternative found in global market including Indonesia to package their products. In order to provide efficient distribution in container whether in sea or air freight, calculating in pallet optimization becomes the method to obtain the purpose.

Distribution efficiency is strongly correlated with pallet use efficiency by the seller and the buyer. Both actors should meet the same pallet size to optimize the pallet space used in container. Qanytah and Ambarsari (2017) stated that various exporters of mango from Indonesia use different sizes of pallet. For example, Cirebon and Pemalang use 1200 × 1000 mm which obtains the most efficient pallet usage if exported to Singapore, Taiwan, Germany and the Netherlands. Besides the size of pallet, the arrangement also contributes to efficiency calculation in distribution. The research also reported that among the various numbers of packaging used for exporting mango, package size of 450 × 220 × 180 mm arranged at 1100 × 900 mm pallet produced by Cirebon resulted in 100% efficiency. While in Pemalang, the efficiency was only 82.12%.

Storage and Ripening

Technology in storage is utilized by applying low temperature combined with additional treatment such as CaCl₂, waxing, edible coating or modified atmosphere packaging which is aimed to improve the consumer acceptance towards quality and delay senescence phase. Technology in ripening conducted through artificial ripening by applying ethylene injection at particular concentration to provide ripening schedule of the products. Some of researches combine storage and ripening treatments so that the results can provide integration system in order to maintain and improve quality of mango during its postharvest growth.

Research in these two stages has relatively been conducted together in order to determine the effect of storage condition on quality after ripening. Paramitha (2009) found that storage temperatures of 8 and 13°C significantly influenced respiration rate, weight loss, firmness, SSC and color during storage of mango cv. Gedong Gincu. The storage and artificial ripening temperatures also significantly influenced respiration rate, weight loss, firmness, SSC, color and sensory acceptance after ripening using 200 ppm ethylene. Based on sensory acceptance, it was found that the best visual acceptance was resulted from storage at 13°C and then followed by ripening at room temperature (27–30°C). Respiration rate and color change develop during storage (up to measurement at 456 hours or 20 days) and followed by ripening are shown in Figs. 1 and 2. Respiration rate during storage relatively decreased showing the maturity growth process up to 456th hour while in ripening changes fluctuate after climacteric peak showed senescence process. The climacteric peak occurred after ethylene injection at the 458th hour. During storage and ripening, there was no increase
Ripening process of mango cv Arumanis could be delayed by 1–3.6 days through immersing the products into CaCl₂ at 4 and 8% concentration for 60, 90 and 120 minutes (Sari et al., 2004). The designed method revealed that calcium infiltration inside the fruits was affected by the length of immersion and not the concentration. Beside the immersion length time, other alternative to infiltrate calcium into the fruits is suggested such as modification in the pressure. Wisnusubroto (1989) reported that application of 145 mmHg could delay 2–4 days ripening rather than infiltration that occurred at normal pressure. To obtain fresher and better visual appearance,
waxing could give good solution as waxing can lighten and close the fruit pores as well as lower respiration and transpiration. In this regard, Purwok et al. (1999) compared application of CaCl₂, PE for packaging material and waxing in mango cv. Arumanis wherein waxing provided the best result for visual appearance and freshness.

ARTIFICIAL RIPENING

Artificial ripening is conducted due to various needs and purposes in preparing mango products from farm to fork i.e., scheduling of matured products to optimize the quality of the products to meet consumer demands at each point of physical distribution along supply chain. This could be in the form of delaying or fastening the ripening process.

The technology of artificial ripening applied for primary mango cv. Indonesia i.e. cv. Gedong Gincu has been conducted in order to study the quality changes as well as developing mathematical modeling of its change during cold storage and after ripening using ethylene 200 mg/kg Rizki (2004) showed that temperature of cold storage and days after ethylene injection interacted which significantly influenced the sensory acceptability including color, texture, taste and aroma. Mathematical modeling to predict quality changes (i.e., weight loss, SSC and acid) during storage had been successfully developed using Arrhenius equation with r is higher than 0.1. The equation and r value are as listed in Table 1.

Table 1: Mathematical modeling to predict quality changes during storage of mango (Gedong Gincu)

<table>
<thead>
<tr>
<th>Quality parameter</th>
<th>Mathematical modeling</th>
<th>Storage temperature (°C)</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight loss</td>
<td>( k = 1.53 \times 10^{-14}, e^{-1018.8/1})</td>
<td>8</td>
<td>0.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13</td>
<td>0.8</td>
</tr>
<tr>
<td>Firmness</td>
<td>( k = 1.40 \times 10^{-7}, e^{-547.7/1})</td>
<td>8</td>
<td>0.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13</td>
<td>0.4</td>
</tr>
<tr>
<td>SSC</td>
<td>( k = 2.39 \times 10^{-7}, e^{-5519.5/1})</td>
<td>8</td>
<td>0.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13</td>
<td>0.9</td>
</tr>
<tr>
<td>Acid content</td>
<td>( k = 6.80 \times 10^{-1}, e^{-1091.7/1})</td>
<td>8</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Source: Riskia (2004)

Chilling Injury

Tropical fruits including mango are susceptible towards low temperature damage or CI with black spot and cell softening occur. But, at the other side, cooling is one of the common technologies used for food preservative through conditioning temperature and relative humidity of its environment which is aimed at minimizing deterioration that can extend the shelf life. The question that emerges is at what condition CI occurs and how to identify...
the initial symptom non-destructively to maintain the intact shape of the products so it is still saleable.

Sutrisno et al. (2010) found that CI occurs at the 4th day storage at temperature below 13°C while at above 13°C it shows at day 4th based on ion leakage parameter. The change of ion leakage from the 0th to 10th days of storage is listed in Table 2. The visual symptom was spot as shown in Fig. 3.

<table>
<thead>
<tr>
<th>Storage (day(s))</th>
<th>Slope</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.140</td>
</tr>
<tr>
<td>2</td>
<td>0.161</td>
</tr>
<tr>
<td>4</td>
<td>0.174</td>
</tr>
<tr>
<td>6</td>
<td>0.149</td>
</tr>
<tr>
<td>8</td>
<td>0.143</td>
</tr>
<tr>
<td>10</td>
<td>0.164</td>
</tr>
</tbody>
</table>

*CI was occurred
Source: Fikri (2011)

![Image of mango before and after ethylene injection](image_url)

**Fig. 3:** Visual appearance of mango before and after ethylene injection at 12th day storage

### PROCESSING

#### Juicy Mango

Puree is the raw material for nectar, juicy, syrup and jams which are obtained by whisking the pulp of the mango without adding water. Puree of mango can also be mixed with other fruits to enrich the taste or nutrient value content. Puree can be packaged using can which needs to be sealed and pasteurized for preservation. Using polyethylene packaging and storage at −30°C through quick freezing using frozen nitrogen for 70 seconds, puree can be stored for six months (Dewandari et al., 2009).

#### Dehydrated Mango

Raymundo et al. (2009) reported dehydrated products of mango in the form of dried, fruit bar, fruit roll and vacuum-puffed dried mango. The principal purpose of this technology is to remove water content in the food making it...
less suitable for undesired microbial growth. The technology development should be reliable with economical and technical ease for manufacturers which the emerging system now is addressing to sun drying system. This technique is sometimes unreliable commercially with production schedule and food hygiene so other techniques using mechanical dryer and vacuum need to be explored more. Mango cracker is one of the products using vacuum frying technique. Before it was fried, the slices were immersed into Natrium metabisulfit 1000 mg/kg for 10 minutes (Dewandari et al., 2009). The temperature and length of time of frying need to be studied further.

**Spray-Dried Mango**

Spray-dried mango is designed to produce mango in powder form through rapid evaporation of H$_2$O or atomizing using heated air flow material. Raymundo et al. (2009) mentioned several advantages in use of this technology i.e. efficient and hygienic method for producing cheap but high quality mango fruit powder and instant mango juice if the proper formulation and parameters are applied; reduced 85% transportation cost; the powder is used for flavoring confectionaries and pharmaceutical preparations; manufacturing baby foods and tropical fruit drinks fortified with nutrients to replace those portions lost during processing and producing instant juice which can be reconstituted easily.

**NON-DESTRUCTIVE TECHNOLOGY FOR QUALITY EVALUATION**

The development of non-destructive technology has been an attractive research for scientists during the growth of robotic technology applied in agriculture particularly for automated harvesting, sorting and grading which robot replaces human job. In developed countries, postharvest activities have been carried out in automated-integrated handling production line which aims to maintain product quality, inclusive of food safety, consistency and avoidance of human error during their work e.g. classification on maturity indices and size which involve adjustment of prediction capability required from human.

Non-destructive technology applied in prediction quality, pests and diseases of mango is NIR spectroscopy (Schmilovitch et al., 2000, Saranwol et al., 2004, Subedi et al., 2007), image processing (Ahmad et al., 2002, 2003), ultrasound method (Mizrach, 2008; Warji et al., 2008) and X-ray (Thom et al., 1995), which in the early development was based on assessment of electromagnetic properties corresponding to physical properties of the products. Present research expands not only include physical but also mechanical and thermal properties.

NIR covers the range of the electromagnetic spectrum between 780 and 2500 nm. When radiation penetrates the product, the incident radiation may be reflected, absorbed or transmitted where the relative phenomena depends on the chemical constitution and physical parameters of the sample.
ogy (Nicolai et al., 2007). It should be noted that the spectra are clearly very similar and this is the reason why sophisticated multivariate statistical analysis techniques are essential to extract useful information from an NIR spectrum (Nicolai et al., 2007). NIR has been used widely in evaluating physiochemical properties of mango (Schmilovitch et al., 2000, Saranwong et al., 2004, Subedi et al., 2007), mangosteen (Teerachaichayut et al., 2011) and avocado (Clark et al., 2003). NIR is an expensive technology, so that the application of NIR in Indonesia for fruits quality evaluation has not been widely developed as yet. This technology had been used initially using reflectant spectra. In other countries, experiments employing NIR for mango were carried out by using short wavelength NIR to examine fruit maturity index at harvest and then to determine final eating quality.

A non-destructive technique using NIRs to predict eating quality of ripe mango fruit in several cultivars from its harvest quality was successfully developed. The experiments were carried out by using short wavelength NIR to examine fruit maturity index at harvest and then to determine final eating quality. NIR absorbance spectra calibration obtained from short wavelength could precisely assess dry matter (DM) and starch content (Saranwong et al., 2004), flesh hunter b and DM content (Subedi et al., 2007) which directly could successfully predict future SSC after ripening stage. Thus prediction was obtained by strong correlation with the ripe-stage eating quality i.e. SSC with DM, starch or flesh hunter b. Table 1 shows an overview of applications of NIR in mango. Sutrisno et al. (2011) studied NIR spectroscopy of mango cv. Gedong Gincu using absorbance spectra which found that the maximum energy is absorbed by starch and it changed every day representing the metabolic process which also changed. The peak energy occurred at 1940 nm as shown in Fig. 4.

![Absorbance spectra of mango cv. Gedong Gincu after storage](image-url)
Besides NIR, ultrasound technology has been used to identify physicochemical properties of mango non-destructively. The wavelength which has been used for industrial and pharmaceutical uses is 0.5–30 MHz, fresh fruits at 0.05–7.5 MHz in which mango is at 0.05 MHz with attenuation coefficient at 4.7–2.16 dB/mm (Mizrach, 2008). Ultrasound also has advantages to identify fruit fly at cv. Arumanis using zero moment power (Mo) (Warji et al., 2008). The result shows that Mo could differentiate infested and uninfected sample with value higher than 5.71 and less than 5.49.

Image processing technology has been used widely to identify visual appearance in sortation and grading activities. In this purpose, automatic grading based on area and texture contrast could be applied in mango cv. Arumanis as well as red color index for cv. Gedong (Ahmad et al., 2004). An important parameter to define the quality value of mango is color. Unfortunately, color is difficult to be evaluated due to its heterogeneity attached among the fruits. Kang et al. (2008) developed color vision system (CVS) technology to evaluate bicolor of mango fruit “B74”. Besides visual appearance, use of volatile to determine fruit maturity is also useful as it presents quality attribute such as SSC and acidity in predefined maturity. With regard to the correlation, Lebrun et al. (2008) showed that electronic nose and gas chromatography could discriminate fruit maturity of mango cv. ‘Cogshall’, ‘Kent’ and ‘Keitt’ by volatile attribute.

Technology to identify postharvest diseases in mango fruit has also been developed. Thomas et al. (1995) developed X-ray imaging to detect damaged fruits caused by seed weevil (Cryptorynchus (Sternochetus) mangiferae (F)). X-ray radiographs of infested mango show dark areas in the seed corresponding to disintegrated kernel tissues as a consequence of feeding by developing grubs while non-infested ones show a uniformly light-grey area representing healthy kernel. Mango rot occurrence could also be detected using ultra-fast GC (Li et al., 2009).

Table 3: Overview of NIR spectroscopy application in postharvest technology of mango (Mangifera indica L.)

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Acquisition mode</th>
<th>Spectral range (nm)</th>
<th>Attribute</th>
<th>SEP</th>
<th>Reference(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tommy Atkins</td>
<td>Reflectance</td>
<td>1200–2400</td>
<td>TSS</td>
<td>1.223</td>
<td>Schmilovich et al. (2000)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Acidity</td>
<td>0.161</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Firmness</td>
<td>17.140</td>
<td></td>
</tr>
<tr>
<td>Caraboa</td>
<td>Absorbance</td>
<td>700–1100</td>
<td>Dry matter</td>
<td>0.41</td>
<td>Saranwong et al. (2004)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Starch</td>
<td>1.71</td>
<td></td>
</tr>
<tr>
<td>Collected from</td>
<td>Absorbance</td>
<td>300–1150</td>
<td>Dry matter</td>
<td>0.01</td>
<td>Subedi et al. (2007)</td>
</tr>
<tr>
<td>different growers in</td>
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<td>the Darwin and</td>
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<td>Katherine regions,</td>
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<tr>
<td>Australia</td>
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CONCLUSIONS

Mango is one of the most popular fruits around the world but this fruit is much perishable due to the susceptibility to physiological, mechanical and pest damage. In order to maintain and improve added value of mango, an appropriate postharvest technology must be conducted and complied with quality standard required by consumers. Even many researchers have been found but so many challenges on handling mango still remain to provide premium quality for consumers with appropriate technology application. Besides of its technique concerns, lack awareness of quality control implemented by growers in some countries is a serious constraint in the point of social view to implement technology.

REFERENCES


Bogor: Department of Agricultural Engineering, Faculty of Agricultural
Engineering, Bogor Agricultural University.


atmosphere and modified humidity packaging alleviates chilling injury symptoms

prochloraz on the control of postharvest decay caused by Alternaria alternata

simpan terhadap daya simpan dan kualitas buah mangga (Mangifera indica L.) varietas
arumanis (The effect of post–harvest treatment and storage temperature towards

arumanis (Used efficiency of corrugated cardboard for distribution of mango cv

International.

penyimpanan buah mangga (Mangifera indica L.) kultivar arumanis dan

quality of mango fruit from its harvest quality measured nondestructively by near

perendaman terhadap umur simpan dan pematangan buah mangga arumanis
(The effect of CaCl₂ and dipping time on shelf life and ripening of arumanis

of mango physiological indices by near–infrared spectrometry. Postharvest Biology

harvest using short–wave near infrared spectrometry. Postharvest Biology

perubahan mutu manggis berbasis perubahan kadar air melalui kecerdasan buatan
dengan tingkat ketelitian 90% (Early detection for quality changes of mangosteen
fruit based on water content through artificial intelligence with accuracy level at

response of fruit and fruit:fly larvae to different heating media. Postharvest Biology
and Technology. 21(1): 51–60.

destructive prediction of hardening pericarp disorder in intact mangosteen by
211.

detection of seed weevil–infested mango fruits by x–ray imaging. Postharvest
Biology and Technology. 5: 161–165.

The mango is a fleshy stone fruit belonging to the genus *Mangifera*, consisting of numerous tropical fruiting trees in the flowering plant family Anacardiaceae. The mango is native to India from where it spread all over the world. It is also the most cultivated fruit of the tropical world and its fruit is distributed essentially worldwide.

Mango is basically a crop well suited for natural farming. In fact before 1950, mango was grown without the use of any chemicals, there used to be enormous variability and superb quality. Use of chemicals was initiated in commercial cultivation of mango after the advent of green revolution. As a result, the number of pests became alarming and now there is always an impression that use of agrochemical is not the ultimate solution for sustainable cultivation of mango.

Looking at the excellent taste, wide variability with respect to varieties, nutritive, therapeutic value, organic production in mango will have immense scope in domestic and export markets.

Mango is the most important horticultural crops of India. It is rightly titled as "King of Fruits" for its wide variability, attractive colours, excellent taste, nutritive, therapeutic values and export potentials. The crop is very well adapted to tropical and subtropical climates. Temperature, rainfall, wind velocity and altitude are the main climatic factors which influence its growth and fruiting. The major constraints in mango cultivation are low productivity, prolonged juvenility, alternate bearing in most of the varieties and incidence of large number of pest and diseases.

The book has two volumes. The volume I deals with Basics, Production, Utilization and Export and volume II with cultivation of mango in different countries. The editors have made sincere efforts to integrate and include modern science such as biotechnology, techniques of mango production, processing, uses, various recipes, marketing and export so that all persons presently concerned or new entrepreneurs can benefit tremendously.

**Readership:** Students of Agriculture, Horticulture, Biotechnology and Botany at B.Sc., M.Sc and Ph.D. levels, nutrition experts, scientists, administrators, policy makers, farmers, processors, exporters and above all housewives and all those concerned with production, processing and marketing of mango. It should form an excellent reference book in all libraries.