Determination of Optimum Maturity of Karuthakolumbaan Mango Fruits (\textit{Mangifera indica}, L.) to Reduce Post Harvest Loss

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Abstract

Mango fruit (\textit{Mangifera indica}, L.) is considered as the king of the fruits in the South Asian countries where they are widely grown. If optimum time for harvesting is determined, then it would reduce the post harvest loss by a big margin. Karuthakolumbaan mangoes are very delicious, comparatively large and economically important for the local public. This work was aimed to determine the appropriate maturity indices for Karuthakolumbaan mango to reduce the post harvest loss due to improper harvesting time. Time after the full bloom stage, the colour of the skin, floating / sinking ability, total soluble solids (TSS), titratable acidity (TTA), moisture content, dry matter, TTS/TTA ratio of the fruits harvested at regular time interval were measured from the mango trees grown in Thirunelvely area, Jaffna. TSS, pH, dry matter content increased rapidly, whereas TTA and moisture content percentage decreased rapidly towards maturity. Fruits harvested up to 94 days from full bloom stage, showed significant differences in the values TSS, pH, dry matter content and moisture content than the fruits harvested after 94 days. Based on the testing panel, the fruits harvested after 95 days from full bloom stage were over-ripened with poor edible quality. This study recommends the appearance of dark yellow colour on either side of the green shoulder, as a non-destructive maturity index that appears on the 94\textsuperscript{th} day from full bloom stage for Karuthakolumbaan mango variety grown in an ideal tropical climate.

Keywords: Karuthakolumbaan, \textit{Mangifera indica}, Maturity index; Full bloom stage, Post Harvesting.

1. Introduction

Mango (\textit{Mangifera indica}, L.), is considered as the king of all fruits because of the taste and benefits in our life of all times. Tropical countries like Pakistan, India, Sri Lanka and Philippines are the largest producers of mango even though they are grown in some countries of subtropical regions. Because of its seasonal nature Mango is grown and yields between March and October in tropical countries. Mango fruit is generally sweet in taste and is the shapes, sizes and colors differ variety to variety. Fruits are processed to produce pickles, milk shakes, desserts, ice creams, smoothies, pies, juices and a lot more different edible items that are of great economic value particularly for the people living in the rural area of these countries. The leaves and the fruits are used for decorations at religious celebrations in different culture. Fruit is nutritionally rich in carbohydrates, sugar, dietary fiber, vitamins, iron, calcium and many other important minerals. Fruit has anti-oxidant properties that help to protect us from various diseases. Anti cancer and antiviral activities were also reported for the fruit (Daud et al., 2010). Chemical composition of mango fruits differs with regard to different cultivars and area of production (Hulme, 1971; Abbasi et al., 2011). There are lots of varieties of mangos available all over the world that includes Ampalavi, Karuthakolumbaan, Kilichondan, Chempadu, Puli, Kent, Edward, Palmer, Ataulfo, Haden, Keitt, Manila, Kesar and many more.

In Sri Lanka, the success of mango cultivation depends on the environmental conditions, harvesting period and the advanced techniques and chemicals used (Kapilan and Anpalagan, 2015). Different mangoes bear fruits at different times in a year (Medlicott, 1985). Due to poor transportation and storage facilities, mangoes produced in remote areas of Sri Lanka are of very low quality and economic value compared to that in the cities. To resolve this situation, the possibility of harvesting mango fruits at optimum maturity to extend.
the shelf-life of the fresh produce needs to be explored. The quality and the postharvest standard of the mango fruit depends on the time and stage of maturity at harvest (Anjum et al., 2006; Jha et al., 2007). However, appropriate quality, taste and smell of the fruits can only be guaranteed when they are harvested at the exact physiological maturity (Reid, 2002; Slaughter, 2009). The physiology and biochemistry of over mature / over ripen fruits differ from that of exactly mature ones in the rates of respiration and transpiration, converting capacity of starch to sugars, susceptibility to pathogen attack and the changes during storage (Hulme, 1971; Kader et al., 2002). Maturity indices of the fruits need to be tested to assure the harvesting of high quality fruits based on the physio-chemical properties (Pal et al., 1987; El-Buluk et al., 1995; Lebrun et al., 2008). Physical parameters of fruit maturity such as weight, size, special appearance, shape, skin colour, number of days from full bloom or fruit set to harvest, specific gravity (Pal et al., 1987) and fruit pressure are widely used as criteria for harvesting diverse fruits (Malevski et al., 1977; Jha et al., 2006; Dick et al., 2009). TSS, total acidity, pH, acid/sugar ratio, reducing sugars, tannins, volatile substances, ascorbic acid and oil content are some of the chemical parameters used to determine the maturity of mango fruits (Hulme, 1971; El-Buluk et al., 1995; Kader, 2002; Abbasi et al., 2011). The number of days from flowering and fruit set to harvest could be a good nondestructive maturity index for diverse fruit varieties (Pal et al., 1987; Lebrun et al., 2008; Dick et al., 2009; Slaughter, 2009). Late harvested fruits are generally sweeter from the earlier-harvested fruits (Lebrun et al., 2008). Mangoes collected very late after flowering developed better organoleptic characteristics than those harvested earlier (Dick et al., 2009). Fruit quality might improve through reduction in Colletotrichum and Dothioriella sp diseases (Hofman et al., 1977). Generally skin colour is used as the standard maturity index for harvesting of mangoes (Hulme, 1971; Malevski et al., 1977; Anjum et al., 2006; Jha et al., 2006; Jha et al., 2007; Abbasi et al., 2011; Lebrun et al., 2008). The change in skin colour from dark-green to light-green or yellow is not a reliable maturity index because of variations between cultivars and tree growing conditions. Mature fruits could ripe with highly preferred taste while immature or over ripened fruits are mostly rejected for consumption (Jha et al., 2007). Using the electronic nose or gas chromatography for aroma and other volatiles as well as for soluble solids and acids, markers are determined (Medlicott, 1985; Lebrun et al., 2008).

Harvesting mangoes in a single picking is the common practice in Sri Lanka and this may result in removal of more immature fruits than mature fruits. Immature mangoes do not ripen naturally when letting to rip out of the tree. Artificial stimulated ripening methods such as fuming or chemical treatment could produce fruits with low quality and poor taste and odour. Therefore, it is very important to harvest the mango fruits at the exact optimum maturity (Medlicott et al., 1986; Kapilan and Anpalagan, 2015). There are a lot of different non-destructive maturities indices used appropriately, for this purpose. The Karuthakolumbaan mango tree is moderately vigorous in fruit production, attaining a spread of 6 - 10 meters and height of 6 - 12 meters at the age of 10 - 12 years. This variety is one of the delicious, high yielding variety that could produce comparatively larger fruits after 5 years of planting in northern Sri Lanka. The fruits are generally green and become yellowish red after ripening. If the fruits are allowed to mature and ripen on the tree, the damage by birds and animals would be very high. In the meantime, if harvesting is done well ahead of the appropriate time of maturity, then the fruits will not reach acceptable eating quality, once the natural ripening process is over. The maturity index of Karuthakolumbaan variety has not been determined yet. Therefore it was decided to determine the maturity indices for harvesting Karuthakolumbaan mango fruits grown under a tropical climatic condition to reduce the loss in the postharvest life of the fruit.

2. Materials and Methods

2.1 Plant Material

Six years old uniform Karuthakolumbaan mango trees (Mangifera indica, L.) were randomly selected in the Thirunvelvely area, Jaffna, Sri Lanka. All trees received the same cultural practices and a single application of farm manure applied annually following harvest and prior to the beginning of the rainy season.

2.2 Harvesting and Maintaining

Around 100 panicles of inflorescences were marked at the full bloom stage and carefully monitored continuously. Tagging of inflorescences was made using a label showing dates of flowering. Ninety days after full bloom stage, 48 fruits were randomly harvested by handpicking from all over the tree by a cloth bag attached to a long pole. Care was taken to obtain fruits of similar size and skin color as an indication for visual analysis. All the fruits were washed with distilled water and air dried. One lot was analyzed as fresh fruits for weight, sinking and floating nature, specific gravity and chemical characters to determine total soluble solids (TTS), pH, titratable acidity (TTA) and TTS/TTA ratio. The other lot was
analyzed, after ripening under laboratory conditions, to determine physical and chemical characteristics, the number of days required for ripening of the fruits and taste. Fruits of the second lot were kept in baskets made from sugar cane sticks and covered with the dried rice grass. Fruits were allowed under regular ripening conditions.

2.3 Analytical Methods

Visual changes were continuously monitored. Fresh weight of the fruit (g) was measured using a top loading sensitive balance. Specific gravity was measured by weighing the fruits first in air and again in water and by observing the fruit whether it sinks or floats in the water. The period required for ripening of fruits kept in baskets was calculated by taking the average period required for all the fruits (10 pieces) to reach ripening. Five grams of mango pulp was weighed in weighing balance and then kept in oven for 48 hours at 60°C. Dry weight was later measured. Dry matter and moisture content (%) were measured using the following formula.

\[
\text{Dry matter} = \frac{\text{Weight after drying}}{5} \times 100
\]

\[
\text{Moisture content (%) = \frac{\text{Fresh weight – Dry weight}}{\text{Fresh weight}} \times 100}
\]

The pulp was crushed using a blender and then filtered through a muslin cloth. Filtered juice was used to measure the following parameters. Titratable acidity measured as % citric acid of fresh mango juice was determined by titrating the sample to pH 8.2 with 0.1 N sodium hydroxide (NaOH) (Ranganna, 1979). The pH of mango juice was measured by the Griffin pH meter. Total Soluble Solids (TSS - Brix) of fresh mango juice was measured by a Kruss hand refractometer model HRN-32. Data obtained were correlated with harvesting date, which was taken as the independent variable. The data were subjected to variance analysis using the R package (R Development Core Team, 2011). Least square means procedure was used to separate treatment means when differences were significant (Zar, 1999).

3. Results and Discussion

The best-tasting mangoes come from the tree-ripened fruits, but fully ripened mangoes cannot be kept long and hard to ship. Ripened mangoes can be eaten by birds and squirrel like animals (Hakkim et al., 2012). During the ripening process of Karuthakolumbaan mango variety, pH of the pulp, dry weight and brix increased towards maturity where as the titratable acidity, moisture content and weight of the whole fruit decreased.

3.1 Visual Appearance of the Fruit

Skin colour of the fruits remained green until ninety second day from full bloom stage and at ninety third day of development, slight yellow colour patch started to form at the shoulder. The slight yellow colour started to change as dark yellow later and then further intensified. This was prominently visible on the ninety fourth day from full bloom stage. On the 97th and 98th days from full bloom stage, the colour spread to one fourth to half of the total skin. The fruits became fully yellow on the 99th day, orange on the 100th day and started to shrink later. Fruits looked like oval until the 9th week from full bloom stage and then started to develop cheek and the shape changed to cylindrical. Decrease of size and sphericity of harvested mango are mainly due to shrinkage (Jha et al., 2006). The internal flesh colour changes from white to cream to various form of yellow in fully ripened mangoes. The weights of both hard and ripened fruits did not show specific trend of change and no significant correlation between fruit weight and harvesting date was recorded.

3.2 Specific Gravity / Sinking and Floating

Most of the fruits harvested after 90 to 93 days from full bloom stage floated in water where as the fruits harvested after 94 days sank in water with a few floating. Specific gravity of both hard and ripe fruits of the Karuthakolumbaan showed fluctuating patterns of increase and decrease with regard to harvest time, without any significant correlations. Generally mangoes with specific gravity higher than 1.0 will sink in water due to higher dry matter content of the fruit (Kosiyachinda et al., 1984). A specific gravity of about 1.02 could be considered as a good maturity index for mangoes (Pal et al., 1987).

3.3 pH

There is a correlation between pH and maturity index in mango (Schmilovitch, 2000; Lebrum, 2008; Dick et al., 2009; Hakkim et al., 2012) and strawberry-
3.4 TTA, TSS, TSS : TTA, Moisture Content and Dry Matter

There was an increase in pH of the fruit pulp, total soluble solid content and dry matter up to 94th day of maturity while titratable acidity and moisture content showed a decreasing trend, up to that level. There was no significant difference among the fruits harvested after 95, 96, 97, 98, 99 and 100 days from full bloom stage in pH, TSS and dry matter (DM).
During the process of fruit maturation, TSS : TTA ratio increased and this revealed the sweetness of the fruit increases towards maturity. This ratio had a significant increase up to 95th day of maturity from full bloom stage. However there was no significant increase in fruits harvested after 95th day of maturity. Changes in the chemical composition after ripening are presented in the tables and the respective figures. TSS of the ripened fruits increased significantly as maturity advanced every day, while TTA and moisture content showed significantly decreasing trend. The fruits harvested after 97 days from full bloom stage showed a
very high TSS : TTA ratio and moisture content. These fruits were of poor quality due to the lower tasting grade, higher susceptibility of spoilage and off-flavour. Dry matter contents of the ripened fruits were significantly higher than the non-ripened fruits. Loss of water during ripening by transpiration through stomata and pores of the skin and the sap that transports the chemicals and sugary contents towards the ripening fruit may be a reason for the raise in the dry matter content (Wills, 1989).

3.5 Taste of the Fruit

The fruits harvested after 94 days from full bloom stage were much sweeter than those harvested
before 94 days from full bloom stage (Tasting panel results are shown in the Table 1). This may be due to the higher TSS : TTA ratio, lower moisture content and aroma generation in the older fruits. Even though the fruits harvested after 96, 97, 98 and 99 days from full bloom stage are of pretty reasonably accepted eating quality, they cannot be left on the tree until development because they are susceptible for bird and animal peck. Mangos collected at 100 days after flowering developed better sugar content and other organoleptic characteristics than earlier harvested fruits (Dick et al., 2009). Using the e-nose and GC for soluble solids, delay in harvesting resulted in sweeter fruits (Lebrun et al., 2008).

3.6 Spoilage Percentage
The fruits harvested after 90, 91, 92 and 93 days from full bloom stage showed higher percentage of spoilage than the fruits harvested after 94 days from full bloom stage. This may be due to the moderate moisture content and higher acidity of the immature fruits. Coatings delayed mango fruit ripening and improved keeping quality and extended storage life with appreciable retention of all quality parameters (Anjum et al., 2006; Abbasi et al., 2011).

3.7 Maturity Index for Harvesting
Harvesting Karuthakolumbaan mangoes at early stage of development (after 90 to 93 days from full bloom stage) is not recommended because of the non acceptable taste of the fruits. Harvesting at very late stage of development (95 to 100 days after full bloom stage) will lead to higher chances of spoilage and the fruits might be eaten by birds and animals when they are on the tree. The occurrence of shrinkage in mango varieties is natural after 95 days from full bloom stage, due to loss of water from the fruit (El-Buluk et al., 1995). Therefore 94th day from full bloom stage would be an ideal choice for harvesting Karuthakolumbaan mangoes. At this stage yellowish colours on either side of the green shoulder would be the skin colour. The values of pH, TSS, DM, TTA and moisture content of the fruit at this stage of maturity, were 5.7, 16.2, 17.5%, 10.4 and 70.6% respectively and these values could be used as maturity indices of Karuthakolumbaa mango variety. When dark yellow colour patches start to form on both the green shoulders, then it is considered as the acceptable maturity index for Kilichondan mango variety and it appears on the 93rd day from full bloom stage (Kapilan and Anpalagan, 2015).

4. Conclusions
The Karuthakolumbaan mangoes growing in the tropical regions could be harvested on the 94th day from full bloom stage. These fruits had satisfactory visible and sensory qualities and recorded as excellent in the tasting panel after ripening. At this stage of maturity, the fruits developed dark yellow colour at both the shoulders. Ripening fruits that contain pH 5.7, TSS 16.2, dry matter 17.5%, moisture content 70.6%, TTA 10.4 could be considered as appropriate maturity indicators for harvesting.

References


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