PHYSICO-CHEMICAL CHANGES IN MUSKMELON (CUCUMIS MELO L.) AS AFFECTED BY HARVEST MATURITY STAGE

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ABSTRACT

This study was carried out in Food Technology Section, Post Harvest Research Centre, AARI, Faisalabad, Pakistan during the year 2010 to investigate the effect of harvest maturity stage on quality of muskmelon (Cucumis melo L.). Muskmelon fruit (cv. Ravi) harvested at immature, half matured and full matured stages were stored at 10°C. The changes in several quality parameters like firmness, pH, total soluble solids, skin and flesh colour were evaluated during storage of 30 days. Significant differences in firmness, TSS, pH, skin and flesh colour were found among different maturity stages of fruit. The melons harvested at half matured (half-slip) stage with persistent stem-end had high external qualities like firmness (12.5-10.0 kg) and colour values (62.8 to 71.89 lightness, -4.55 to 8.9 red to green and 54.70 to 48.48 blue to yellow). The best internal quality was verified with respect to TSS (8.0-13.0%) and acidity (0.13-0.21%).

KEYWORDS: Cucumis melo; maturity; chemico-physical properties; Pakistan.

INTRODUCTION

Muskmelon (Cucumis melo L.) belongs to Cucurbitaceae family with fibrous and shallow root system. It is 4th important fruit in the world fresh fruit market with several varieties and serves as major food sources (13). This botanical group includes cantaloupe, honeydew and casaba. Cantaloupe fruit (C. melo var. reticulate naud.) is usually characterized by netted surfaces with shallow vein tracts and flesh is salmon-coloured. Muskmelon is native to North Western parts of India and its primary center of origin is hot valley of Iran and adjacent areas; now growing world-wide in both tropical and temperate regions (14).

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Muskmelon is a delicious fruit of common man. Its flesh and seeds both have high nutritive value. Muskmelon is a rich source of vitamin A, C, ß-carotene, carbohydrates, sugars, protein and traces of vitamin K, B₁, B₂, B₆ and niacin. In addition, fruit contains more than 90 percent water (15). Its seeds contain 40-44 percent oil and used as a substitute of almond and pistachio. The fruit pulp and juice is used in refreshing drinks. Fruit pulp contains 94 percent water, 5 percent carbohydrates, 1 percent protein, 3420 IU of vitamin A and 33 mg vitamin C (3).

Maturity indices play a very important role in the post harvest quality management of cantaloupes. Maturity indices are the indicators that ensure the best eating quality to the consumer and provide flexibility in marketing. Post harvest physiology can be affected by cultivar, environmental condition and also by harvest time (9). Harvest time is fundamental to obtain a high quality fruit with storage potential. It was reported that in melons both maximum respiratory activity and ethylene production are dependent on fruit maturity at harvest (6). Only melons harvested at early maturity stages exhibit the climacteric pattern (12).

Harvest time also has influence on the fruit sensorial qualities. Bananas harvested at more advanced maturity stage had better consumer acceptance (1). Knee and Smith (11) verified that apples harvested at precocious maturity stages showed good conservation but presented an unsatisfactory flavour and colour when ripe. Maturity stage at harvest time also affects the biosynthesis of volatile components in mangoes, responsible for fruit flavour (12). Harvest maturity studies on melons are lacking. Slipping is a proper criterion of maturity index in muskmelon but is difficult to ascertain and requires well trained labours (5). As a maturity index, ground colour has the advantage of being non-destructive and easy to determine (6). Ground colour has been used as an indication of maturity in harvesting several fruits including bananas, peach, watermelon and guava.

This research was planned to determine optimum harvest maturity stage of muskmelon with better shelf life and quality retention.

**MATERIALS AND METHODS**

**Procurement of samples**

Muskmelon fruit (cv. Ravi) procured from Vegetable Research Institute, AARI, Faisalabad during the year 2010 was washed and pre-cooled in Food...
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Technology Section, Post Harvest Research Centre, AARI, Faisalabad, Pakistan. Treatments were made according to their maturity stage i.e. T1 was fruit harvested at pre-mature stage or ¼ slip stage (fruit harvested when it reached a stage of development just prior to beginning of abscission crack around stem), T2 was the half matured fruit harvested at half-slip stage when abscission crack progressed one half distance around the stem and T3 was full matured fruit harvested at full-slip stage when abscission crack progressed completely around stem and slight indication of yellow colour of fruit. Typically full-slip stage is 42 days after flowering.

Sorting and grading

The homogenous samples of uniform, similar size and weight were isolated from the diseased, damaged and bruised fruits and selected for further studies.

Pre-cooling

After harvesting, the fruits were put into Air Blast Cooling Unit at 10°C for pre-cooling. After attaining the required temperature i.e. 15°C pre-cooled fruits were shifted to Reefer Container compartment mobile unit which was already set and maintained at 15°C.

Washing with anti-microbial solution

The harvested fruits were washed with sodium hypochlorite solution (200 ppm) to keep safe from microbial contamination.

Storage conditions

Fruits of all treatments were stored in cold storage chamber at low temperature i.e. 10±2°C with relative humidity of 85-90 percent.

Physico-chemical analyses

Firmness: Firmness was determined at the equatorial part of fruit of each treatment with penetrometer (PCE-PTR-200) with 3mm probe after 5 days interval for 30 days of storage.

Total soluble solids (TSS): TSS was determined by Refractometer (Abbe Refractometer Model 2WAJ). A few drops of well homogenized sample were
taken on prism of Refractometer and direct reading was taken by reading the scale in meter.

**pH measurement:** pH was determined with a digital sharp probe pH meter (model) (InoLab 720, Germany), which was previously standardized to pH 7.

**Acidity:** The acidity in each sample was determined according to standard procedure given in AOAC (4). Sample was titrated with 0.1 N NaOH using phenolphthalein as an indicator (1-2 drops) till light pink end point which persisted for three seconds.

**Skin/flesh colour:** The colour values of fruit samples were measured using the L*, a* and b* colour space (CIE-LAB Space) with Colour Tech-PCM (USA) (Fig. 1). The L* value indicates lightness, a* and b* values are chromaticity coordinates (a*, from red to green; b*, from yellow to blue). The melon flesh and skin colour was measured for L* (lightness), a*[green (-) to red (+)], b* [blue (-) to yellow (+)] (Fig. 1).

**Sensory evaluation:** Sensory evaluation, based on colour, flavour, taste and overall acceptability was conducted after every week. A 9-point hedonic scale was used for evaluation.

**Statistical analysis**

The data obtained were statistically analyzed for analysis of variance (ANOVA) using 2-factorial completely randomized design (CRD) and means were compared with DMRT using LSD at P≤0.05 according to the method described by Steel et al. (19).

**RESULTS AND DISCUSSION**

**Firmness**

The data (Fig.1) showed that overall means regarding treatments for firmness significantly differed from each other and varied from 14.7 to 8.4 kg. Muskemelon samples of all three stages showed a rapid decrease in flesh firmness. Melon fruit harvested at full mature stage (T3) showed an extreme flesh softening during storage that limited their storability and shelf-life. Mean values of treatments also revealed that fruit harvested at more advanced maturity stage had lower pulp firmness as compared to that harvested at earlier stages. Firmness variation in T1 is possibly due to the reason that in early maturity stages the enzymes related to softening were still not completely synthesized and activated.
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These results are in conformity with those of Beaulieu and Lee (8) who observed that rate of firmness loss is affected by maturity stage at harvest. At the end of storage, fruit harvested at immature stage (T1) lost approximately 42.5 percent of initial firmness and more than 60 percent when harvested at half mature (T2) and full mature (T3) stages as the quantity of ethylene receptors is reduced in fruit harvested when still green.

**Total soluble solids**

The results (Fig. 2) revealed that overall mean values of TSS in different treatments varied from 5.0-8.5 percent for T1, 8.0 to 13.0 percent for T2 and
10 to 16.0 percent for \( T_3 \), while with respect to storage, TSS varied from 7.66-12.50 percent. These results showed significant difference in TSS contents among all treatments which is due to maturity stage at the time of harvest. Fruit harvested at half maturity (T\(_2\)) was even sweeter at the end of storage as compared to that of immatured (T\(_1\)) and fully matured fruit (T\(_3\)). T\(_3\) showed an immense decline in storage quality. The deviation in soluble solid contents of fruit might be due to variation in metabolism and respiration rate among different treatments (maturity stages).

Beaulieu and Lea (8) also reported an increase in sugar from 5-11 percent during ripening in melon. Contrarily Simandjuntak et al. (16) reported decrease in sugar contents i.e. from 11 to 9.8 percent during ripening in Cantaloupe and Honey dew melons. The change in TSS with advancement in maturity in this study is attributed to metabolism of sugar due to increased respiration with high temperature. Harvest of melon at proper maturity stage (when TSS is about 8-10%) is crucial to good eating quality (5).

**pH**

The pH of fruit did not change appreciably during storage. However, marked difference was observed among the treatments. The change in pH was consistent with the passage of time but there was a decreasing trend for all treatments gradually. The pH values within treatments varied from 5.58 to 5.54, 5.50 to 5.45 and 5.38 to 5.29 at the end of storage of 30 days for T\(_1\), T\(_2\) and T\(_3\), respectively (Fig. 3). These results coincide with those of Augustin et al. (7) and Beaulieu and Lea (8) who reported a similar pattern of pH value (5.25, 6.51 and 6.79) in Cantaloupe variety during storage, harvested at

![Fig.3 Effect of treatments and storage on pH value of muskmelon.](image)
different maturity stages. There is slight variation in pH value of fruit harvested at immature stage as compared to half matured and fully matured fruit that is attributed to low metabolic rate and significant variation among all treatments showed a decline in pH with advancement of maturity.

**Titratable acidity**

The data (Fig. 4) indicated significant difference in acidity (0.66-0.68%) among treatments and a significant increase in acidity with respect to storage period was observed. The results further revealed that titratable acidity of muskmelon increased from 0.12 to 0.18, 0.13 to 0.21 and 0.14 to 0.25 percent during storage for T1, T2 and T3 respectively. In case of immature muskmelon (T1) titratable acidity was not as much higher as that of half matured (T2) and full matured (T3) fruit during storage. This difference is due to degradation of sugars into high acid compounds while in immature fruit ripening as well as degradation process is slow which ultimately results in low acidity percentage. These results are similar to those of Augustin et al. (7) who worked on physico-chemical changes in muskmelon during storage and observed 0.15-0.27 percent acidity.

**Skin/flesh colour**

**Skin color:** During storage, fruit harvested at full maturity stage showed an increase in yellow colour development. There was a significant difference (P
≤ 0.05) between the levels of fruit maturity stages for $L^*$, $a^*$, $b^*$ values (Fig. 5 and 6). A positive correlation was observed between the treatments and $a^*$ value. The $a^*$ value was increased when melon fruit reached from immatures to full matured stage. An increase in $a^*$ value means a decrease in the degree of greenness. Maximum values of $a^*$ were found at initial stage i.e. -11.64 for $T_1$, -8.98 for $T_2$ and -7.64 for $T_3$ and at the end of storage reached to -7.66, -4.55 and -3.24 for $T_1$, $T_2$ and $T_3$, respectively. These changes during ripening period (loss of greenness) occurred as a result of breakdown of chlorophyll pigments in the peel tissues. The change of peel colour from mature green to yellow was due to accumulation of carotenoids and chlorophyll degradation at thylakoid membrane through chlorophyllase and
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oxidase enzymes. The variation in Lab values among all maturity stages is because of dissimilarity in rate of ethylene production as well as enzyme activity as there is low enzyme activity in immatured fruit as compared to that in half matured and full matured fruit.

The value of $b^*$ increased between stages one and three, and ranged from 25.45 -31.03 in $T_1$, 48.48-54.70 in $T_2$ and 58.02-63.04 in $T_3$. Similarly, $L^*$ varied in same fashion (Fig. 6). These results are in close agreement to those of earlier workers (17) who had studied the saturation or chroma in banana fruit which is a function of $a^*$ and $b^*$. The values of $a^*$ were smaller than $b^*$ values, so the effect of $a^*$ on chroma was poor. Therefore, values of chroma were approximately equal to $b^*$ i.e. $a^*$ value decreased with increase in $b^*$ value during ripening.

**Flesh colour:** In muskmelon flesh, intensity of orange colour is an important quality characteristic. The colour is primarily due to carotenoid pigments. The values for $L^*$, $a^*$ and $b^*$ significantly varied in all treatments (Fig. 7). The graphical presentation of mean values showed significant variation among treatments and non-significant variation during storage. The mean values for $L^*$, $a^*$ and $b^*$ were 65.25, -4.65 and 23.47 for immaturityd fruit ($T_1$), 65.34, -4.24, 31.86 for half matured fruit ($T_2$) and 66.76, -3.14, 34.62 for full matured fruit ($T_3$). During storage period of 30 days, $L^*$ and $b^*$ values showed decreasing pattern with non-significant change in $a^*$ value. The colour variation within treatments is due to the burst of ethylene gas that signals genes to transform chloroplasts, chlorophyll is gradually replaced by the carotenoids, and fruit slowly changes colour at immature stage and rapidly at mature and half mature stages. Similar results were reported by Ahmed (2)
while studying the objective maturity indices of muskmelon. Beaulieu and Lea (8) also reported similar results regarding change in flesh colour of stored Cantaloupe harvested at different maturity stages. The L*, a* and b* values varied from 65.05-66.77, 12.82-13.49 and 39.13-40.30, respectively. Also Supapanich and Tucker (18) observed L*, a* and b* values of 73.9, -4.6 and 12.5, respectively during storage. Decrease in L* and b* values of minimally processed muskmelon fruit are related to the development of translucent or water-soaking symptom. However, this study showed no development of translucent and water-soaking symptom in muskmelon fruit over storage.

Sensory analysis

The data indicated significant differences in sensory parameters for muskmelons harvested at different stages. The panelists discriminated numerous significant sensorial differences between quarter slip compared with full slip stage. However, they did not find significant differences between half-slip and full-slip melons for colour, flavour, texture or texture attributes (Fig. 8). Using hedonic scales, panelists found differences in taste and

![Fig. 8. Effect of treatments and storage on sensory parameters of muskmelon.](image)

flavour as well as in texture between half slip and full slip muskmelons during storage. They categorised fruits harvested at half mature stage as the best on the basis of taste, flavour, texture and overall acceptability. The reason is that there was a balance in all biochemical changes i.e. ripening, ethylene production and enzymes activity for the suitable taste, texture, colour and flavour development, while in case of immatured fruit low level of ethylene, non-availability of specific enzymes etc. the required characteristics were not appeared, hence gained low scores by the panelists. Also fruit harvested at full matured stage was not liked by the panelists as high respiration rate, high

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Ethylene production and enzymes, activity resulted in loss of texture, colour, development of off-flavour. Similar results were observed by Evensen (10), who studied fresh cut melon fruit harvested at various stages of maturity. In this study, scores for quarter-slip melons were low because of lack of melon flavour. Half-slip (half mature) melons maintained the sensory scores during 30 days. Fruit of T₁ (harvested at quarter slip or immATUREd stage) as well as T₂ (fruits harvested at half-slip or half mature stage) and T₃ (fruits harvested at full-slip or full mature stage) did not hold up during storage. T₃ also exhibited low scores as compared to T₂.

CONCLUSION

In this study a significant difference was found in physico-chemical parameters as well as in sensory attributes among all treatments. It was found that colour; firmness and TSS had a good co-relation with the maturity stage at harvesting time and influenced the storage quality. Muskmelon harvested at half maturity (at half-slip) was better in storage quality regarding TSS, pH, acidity and colour. It had also good flavour and aroma with low firmness. Unfortunately melons harvested at full slip had a short storage life with low quality attributes. Muskmelons harvested prior to full slip were high in firmness, TSS, pH and low in acidity having poor flavour, taste and texture.

REFERENCES


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