J. Agric. Sci. Mansoura Univ., 33 (3): 2091 - 2109, 2008

CERDIBILITY OF ANALYSIS RESULTS OF MANGO FRUIT QUALITY IN RELATION TO DIVERSE METHODS OF COLOUR AND FIRMNESS EVALUATION

Sobeih, M. E.[1]; Amira A. El-Helaly [2] and Fatma E. Ibrahim[1]
[1] Horticulture Research Institute, A.R.C. Giza, Egypt
[2] Hort. Res. Station Sabahia, Alex., Hort. Res. Ins., A.R.C., Giza, Egypt

ABSTRACT

Green mango fruits (*Mangifera indica* L.) cvs. (Ewais and Zebda) were harvested at proper stage of maturity. Fruits were ripened by acetylene gas and kept at 23°C ± 1 and 85% RH± 2 for 8 days (analyzed every 2 days) or stored at 14°C or 18°C and 85% ± 2 RH for 3 weeks (analyzed weekly). Ewais and Zebda mango fruits characteristics were monitored by analyzing peel and pulp colour (*L**, *a**, *b**, a/b , La/b, hue angle (h°), chroma (*C*) and rating colour index), total soluble solids, total acidity and fruit firmness (by instrumental measurements or by sensory evaluation). a* value, La/b and hue of Ewais and Zebda (peel or pulp) proved to be credible and reliable criteria, due to their correlation coefficients (high negative or positive correlation between them and ripening parameters, a/b and La/b of peel and pulp). According to correlation coefficients test, it was impossible to rely on both b* value and chroma of Zebda peel or pulp. Firmness by hand (sensory evaluation) could be considered as a reliable and credible indicator for ripening progress of Ewais or Zebda mango fruits, because of its ability to evaluate firmness till the end of ripening stages, while instrumental methods could not read firmness at the final stages of ripening or directly before them. Results emphasized the benefit of sensory evaluation as an essential indicator for ripening progress of mango fruits.

Keywords: fruit quality characteristics, reliability, credibility colour development, firmness and sensory evaluation.

INTRODUCTION

Mango (*Mangifera indica* L.) is a tropical fruit originated in the Indo-Burma region and has been cultivated for over 4000 years in India (Nakasone and Paull, 1998). It is the second most important tropical fruit crop in the world (next to bananas).

The external colour of mango fruits produced is an important factor in consumer appeal (Campbell and Campbell, 2002). It has been reported that colour development of ripening mangos is due to progressive synthesis of carotenoids and degradation of chlorophyll (Gowda and Huddar, 2001 and Lizada, 1991). Peel colour of the fruit changes during ripening as chloroplast in the peel is converted into chromoplasts, which has red or yellow pigments, while some cultivars show reddish blush because of anthocyanins, while some remain green (Lizada, 1993). Mitcham, *et al*. (1996) noted that the evaluation of mango colour has been subjective (based on visual ratings by human eye) or objective (instrumentally). They also stated that subjective scoring of colour might be more practical and faster and values could be referenced to objective colour values and to pigment concentrations. For Routine, evaluations are done by subjective scoring, but referencing to objective measurements adds valuable information to the scores.

Colour reflection techniques values (objective methods), have been developed which provide tristimulus values, from which the chromatic coordinates on the CIELAB colour system (Commission Internationale d'Eclairage) can be acquired (McGuire, 1992). The colorimeter generates a composite, three parameter L*a*b* number. Results of fruit colour measurement (L, a, b values) were selected and demonstrated as 'L, a, b' values (Shivashankara *et al*., 2004 and Sobieh and Hassan, 2007), a, b values (Jha *et al*., 2007), a/b (El-Oraby *et al*., 2004), hue angle (Ayala-Silva *et al.*, 2005) and Chroma (Ortega-Zaleta and Yahia, 2000).

Researchers adopted such attitudes of demonstrating L a b values depending on their view of the best way of expressing results, which agrees with accurate visual observations. Once obtained, this information could be used to assist in mango development programs.

Fruit firmness changes have been a reliable way to describe ripening changes (Kader, 1992). Softening during mango ripening is accomplished by solubilization of pectin (Brinson *et al.*, 1988). The measurement of texture is an important criterion and it can be measured by instrumental or by sensory methods. Instrumental method is more sensitive and reproducible. Until recently, methods of assessing fruit texture properties nondestructively were not commercial (Valero *et al*., 2007). Abbott and Harker (2000) noted that instrumental measurements were preferred over sensory evaluations for research and commercial applications, because instruments reduced variation among measurements dueto human factors, they were more precise and could provide a common language among researchers, companies, regulatory agencies and customers. They also added that texture could still only be fully measured by sensory evaluation. Moreover, Polderdijk *et al.* (2000) found that the best applicable method for measuring firmness of mango (a nondestructive acoustic, mechanically and manually according to a sensoric scale) proved to be the manual method. In addition, Abbott *et al*. (1997) stated that only people could judge quality, but instruments that measured quality-related attributes were vital for research and inspection.

Hence, this work was conducted to evaluate reliability and credibility of both colour and firmness readings as indicators for the actual ripening development.

MATERIALS AND METHODS

The present study was carried out during the two successive seasons of 2005 and 2006. Ewais and Zebda mango fruits were harvested at proper stage of maturity from a commercial orchard located in Al-Fayoum. The fruits were washed, air dried and packed in carton boxes, where each box contained a single layer (approx. 3 Kg). Then, fruits were divided into three groups, each group had 3 replicates and each replicate contained 9 carton boxes. The first group was kept in a ripening room at 23°C $\pm$ 1 and 85 % $\pm$ 2 RH and ripened by acetylene gas (released from calcium carbide 2 g/kg. fruit according to Kumar *et al*., 1996). The second and third groups were stored at 14°C and 18°C and 85% $\pm$ 2 relative humidity, respectively. Fruit quality parameters of ripened fruits were analyzed every 2 days, whereas stored groups were monitored weekly as follows:

Peel and pulp colour measurement : It was determined by using a Hunter colorimeter type (DP-9000) for the estimation of L, a, b, hue angle (h°) and chroma (*C*). In this system of colour representation the values *L**, *a**, and *b** describe a uniform three-dimensional colour space, where the *L** value corresponds to a dark-bright scale, *a** is negative for green, and positive for red, and *b** is negative for blue and positive for yellow. From L, a & b values, a/b and La/b were calculated. From L, a & b values, a/b and La/b were calculated. Hue angle and Chroma as described by McGuire (1992): hue (*h*= arc tan b*/a*) determines the red, yellow, green, blue, purple, or intermediate colours between adjacent pairs of these basic colours Hue angle (0°= red-purple, 90° = yellow, 180°=bluish-green, 270°= blue). Chroma (*C*) (*C*= [(a*)2 + (b*)2]0.5).

Total soluble solids % : Abbé refractometer was used to determine the percentage of total soluble solids in fruit juice (AOAC, 1990).

Titratable acidity % : It was determined in terms of anhydrous citric acid percentage after titration against 0.1 N sodium hydroxide using phenole-phthaline as an indicator (AOAC, 1990).

Fruit firmness of Ewais and Zebdda fruits was recorded from both sides on individual fruit after peeling a portion of the exocarp using :

1: Texture analyzer : firmness was recorded by a lfra texture analyzer instrument, using a penetrating cylinder of 1 mm of diameter, to a constant distance(0.3&0.5 cm depth) inside the pulp (without peel), and by a constant speed, 2mm/sec, and the results were expressed as the resistance force to the penetrating tester, in units of pressure per gram (g.mm).

2: Effe-gi penetrometer mounted on a drill-press stand, having a probe of 0.79 cm. width. Fruit firmness was recorded in Kg/cm^2.

Sensory Evaluation :

Peel colour index was evaluated visually on a scale 1 to 5m with 1= dark or light green, 2 = 1/4 yellow, 3 = 1/2 yellow, 4 = 3/4 yellow and 5 = fully coloured.

Pulp colour index was evaluated visually on peeled fruits on a scale 1 to 5 with 1 = white, 2 = slightly yellow, 3 = moderately yellow/orange, 4 = dark yellow and 5 = full yellow/orange.

Stage of ripening (or firmness by hand) : According to Miller *et al*. (1991), stage of ripening was subjectively rated on a scale of 1 to 5, where 5 = overripe [very soft, very slight resistance to moderately applied finger pressure (MAFP)], 4 = soft-ripe (eating stage, slight resistance to MAFP), 3 = partially ripe, fairly soft (moderate yield to MAFP), 2 = fairly inedible, fairly hard (slight yield to MAFP), and 1 = inedible, hard (no yield to MAFP).

Statistical analysis :

The obtained data were statistically analyzed using excel micro software (one factor randomized complete block design) according to Snedecor and Cochran (1990) and the LSD test at 5% was applied to

compare the effects of duration on ripening or storage parameters. Simple correlation coefficients among different parameters were computed, according to Snedecor and Cochran (1990).

RESULTS AND DISCUSSION

Peel and pulp colour development : colour of fruits plays an important role in fruit consumption and is one of the most important quality attributes in the selection process.

The development of L, a, b values, a/b, La/b, hue angle ,chroma and colour index recorded during ripening Ewais (coloured mango) and Zebdda (green, uncoloured mango) fruits at ambient temperature or stored at 14&18 C is presented in Tables (1, 2, 3 & 4) L* values : Data indicated that L* values of peel colour increased towards the end of ripening or storage period (indicating lighter colour), and the greater luminosity (highest *L** values) was obtained at the last stage of ripening or storage in both cultivars, in both seasons. On the contrary L* values of pulp colour declined towards the end of ripening or storage period. After 3 weeks, the increase of L* values of peel colour and decrease of pulp colour were higher in fruits stored at 18°C than those stored at 14°C.

Regarding the increase of L* values of peel colour and decrease of pulp colour, obtained results were in harmony with those reported by Sobeih and El-Helally (2002) on Alphonso fruits and El-Bassiouny, (2003) on Ewais fruits and Sobieh and Hassan (2007) on Keitt mango fruits. UEDA *et al*. (2001), reported that the *L* value of flesh colour decreased with ripening.

a* values:

The increase in a* value of peel or pulp colour in Ewais and Zebdda was particularly marked. Moreover, the a* value of peel in the early stage of ripening Ewais fruits was negative while positive values increased with the progress of ripening process (indicating changes into yellow from green). Behaviour of uncoloured mango, Zebdda fruits were different, as its peel kept negative values till the end of ripening or storage period. Pulp of Ewais and Zebdda had positive a* value from maturity stage till the end of storage period (indicating a change to dark orange from very light yellow). Similar results were obtained by Sobeih and El-Helaly (2002), who noted that mature Alphonso mango fruits still had negative a* values, while positive values increased with the progress of ripening process.

B* values: Data showed that yellow-blue components (*b** values) slightly increased in peel in both cultivars, in both seasons. All b* values of Ewais peel and pulp (coloured mango) were higher than Zebdda (green, uncoloured mango).

It is related to formation of yellow pigments. These changes in Hunter colour values were also in agreement with visual observations (colour index), in both cultivars, in both seasons.

1

3

Regarding the increasing of b* values of peel or pulp colour, results were in line with those of Ueda *et al*. (2001), Shivashankara *et al*. (2004) and Sobieh and Hassan, (2007), who pointed out that peel and pulp b* values increased during the storage. Zambrano and Materano (1998) found that high correlation coefficients were observed between carotenoid content and b* values*, hue, and chroma.

a/b : a/b of the Ewais peel increased from negative values (-0.58) & (-0.54) to positive (0.30 - 0.31), while a/b of the flesh increased from (0.02 - 0.03) to (0.23 - 0.25) at the end of ripening period. a/b of the Zebdda peel kept negative values till the end of ripening period, it increased from (-1.56) & (-1.52) to (-0.56) & (-0.52), while a/b of the flesh increased from (0.03-0.04) to 0.24 at the end of ripening.

La/b: Similar trend as that of a/b peel pulp values was observed, but La/b range of values was extremely wider. These results were in line with those obtained by Kajuna *et al*. (1995), who concluded that the La/ b system was a potential method for replacing the subjective colour chart method in determining the peel colour.

hue angle decreased continuously towards the end of ripening and storage period in both cultivars, in both seasons. The decrease in "hue angle" in peel means that external colour developed from green to yellow. Hue angle " in pulp means that colour developed from very light yellow to dark orange. Thus, it was obvious that the decrease of peel hue was more than the decrease of pulp hue in both cultivars and both seasons. Squinty peel hue range of values was extremely wider and pulp hue was obvious. These results coincided with those of Hidalgo *et al*. (1997), and De Mann (1999), who reported that peel hue angle decreased during ripening and a decrease of hue angle in edible mango flesh represented a change from green to yellow to red.

Peel & Pulp Chroma : Loss in chroma indicated a loss of pulp colour intensity. It was also an indication of browning. Peel chroma of Ewais (coloured mango) increased gradually with ripening progress and storage duration, while pulp chroma decreased. On the contrary, peel chroma of Zebda (green, uncoloured mango) gradually decreased with ripening progress and storage duration, while pulp chroma increased. The difference between Ewais peel & pulp chroma and that of Zebda might be due to the different kinds of pigment or colouring behaviours that displayed a concomitant drop in chroma values, which suggests a loss of colour purity. These results agreed with those obtained by Jacobi and Giles (1997), who reported that higher skin colour ratings, chroma values and lower hue angles indicated an enhancement of ripening. Ortega-Zaleta and Yahia (2000) also noted that chroma of Manila mangos exocarp and mesocarp decreased.

Colour Index: Colour index of Ewais mango fruits significantly increased in both peel and pulp during both seasons, while only colour index of Zebdda pulp increased significantly. These results agreed with those obtained by

Gowda and Huddar (2001), who stated that the peel colour of mango turned from light green, green or dark green to light yellow, yellow or orange yellow, whereas pulp colour changed from white or pale yellow to yellow, deep yellow or orange yellow.

Total soluble solids % : The accumulation of total soluble solids recorded during ripening or storage at 14 & 18 °C is presented in Tables (5 & 6). Data showed that a gradual significant increase of T.S.S % towards the ripening stage or till the end of storage period was observed in both seasons, and both cultivars**.** Data also indicated that Ewais mango fruits had higher TSS content than that in Zebdda fruits in both seasons. These results were confirmed by Araiza *et al*. (2005), and Sobieh and Hassan (2007), who pointed out that the levels of total soluble solids (TSS), increased gradually during storage. The increase in TSS % might be due to the alteration in cell wall structure and breakdown storage.

Regarding the effect of temperature, it was noticeable that the T.S.S.% was higher in fruits stored at 18°C compared to those stored at 14°C till the end of storage period in both cultivars. Similar results were obtained by Manzano *et al*. (1997), who noted that temperature of storage affect TSS contents.

Titratable acidity % : Tabulated data (5 & 6) showed that titratable acidity significantly decreased towards the end of ripening or storage periods. Data also showed that total acidity of Ewais mango fruits was higher than that of Zebdda fruits at harvest time and less during ripening or at the end of storage period. Titratable acidity of Ewais mango fruits decreased from 2.45-2.79 % at harvest time to 0.40% after 3 weeks of storage at 14°C and to 0.29-0.33% at 18°C, while Zebdda fruits decreased from 1.88-1.97 % at harvest time to 0.65-0.74 % after 3 weeks of storage at 14°C and to 0.50-0.55% at 18°C. These results coincided with those of Yeshitela *et al.* (2003) and Rathore *et al.* (2007), who reported that the major change was a considerable decrease in acidity during ripening. Results also confirmed the previous results obtained by Gowda and Huddar (2001), who found that acidity in different varieties of mango fruit stored at 18-34 °C decreased from 2.71 to 0.04% during ripening.

Pulp firmness: Firmness is one of the important quality parameters in sensory evaluation, which plays an important role at time of selection of fruit by consumer. It is clear from Tables 5 & 6 that pulp firmness measured by texture analyzer or by Effe-gi penetrometer decreased gradually towards the end of ripening or storage period in both cultivars, in both seasons. The obtained data clearly indicated that instrumental measurements were not able to read firmness (penetration force) at ripe stage 4 (soft-ripe, eating stage) or before (ripe stage 3, partially ripe), or after 2 weeks storage at 18°C in both cultivars, and both seasons. Firmness measured by texture analyzer (0.3 cm depth) had the least ability to record firmness reading. Texture analyzer couldn't read fruit firmness after 2 days. Consequently, it was the most unreliable method for reading fruit firmness.

Pulp firmness of Ewais measured by texture analyzer (0.5 cm depth) ranged between 145.0 and 151.0 *g.mm* at harvest time and then decreased to 22.9-23.0 *g.mm* after only 4 days from ripening. No reading after that was possible. However, pulp firmness of Zebdda ranged between 169.0-183.2 *g.mm* at harvest time and then decreased to 17.1-22.6 *g.mm* after 6 days only from ripening. No reading after that was possible as well.

Penetration force measured by Effe-gi penetrometer decreased and showed the same trend observed with the decrease of pulp firmness measured by texture analyzer (0.5 cm depth), in most cases. No reading at the end of ripening duration was recorded, similar to the case of pulp firmness measured by texture analyzer. These results are corresponding to those obtained by Rathore *et al.* (2007) and Sobieh and Hassan (2007), who noted that as fruits ripened, flesh firmness decreased. Wen *et al.* (2006) found that pulp firmness decreased dramatically at 6 days after harvest. Regarding the differences between mango cultivars in pulp firmness, obtained results were agreed to some extent with those obtained by Araiza *et al.* (2005) who stated that 'Tommy Atkins' presented firmer fruits at the end of the study with 35.5 N, while 'Osteen' was softer with 5.7 N.

Regarding impossibility of reading fruit firmness at the end of storage period or before the end, it coincided with results obtained by Sergent *et al.* (1993), who noted that firmness of Keitt mango fruits decreased and then levelled off in a similar way.

Concerning the effect of storage temperature, it was noticeable that the fruits firmness was higher in fruits stored at 14°C compared to those stored at 18°C for the same storage period. These findings correlated with Opara *et al*. (2000) and Ortega-Zaleta and Yahia (2000), who reported that firmness of mango fruits was highly dependent on storage temperature. Fruit firmness losses decreased as temperature increased.

The reduction in firmness during storage, might be due to the breakdown of insoluble pectic substances to soluble forms by a series of physicochemical changes that caused by the action of pectic enzymes i.e. esterase and polygalacturonidase formed in the tissues during ripening stages (Weichmann, 1987).

Credibility & reliability in this study were depend on statistical analysis using correlation coefficients between all parameters (Table 7, 8), the LSD test ($P < 0.05$) and how wide the range between the highest and the least values of the same parameter.

Ewais : Although values of Ewais peel or pulp colour parameter had high correlation (negative or positive) between them and ripening parameters (TSS, acidity, firmness and ripe stage), a* values, a/b, L a/b and hue had higher correlation between them and ripening parameters (TSS, acidity, firmness and ripe stage) compared to both b* values and chroma. This was confirmed by finding out that peel chroma had simple correlation with both peel colour index and firmness measured by Effe-gi penetrometer. Insignificant correlation between peel chroma and firmness measured by texture analyzer (0.3 cm depth) was observed.

In general, chroma couldn't reflect the change from negative a* values (indicated green colour) to positive a* values (yellow, red or breakdown of green colour). If b* value didn't change and a* value changed from negative to the same positive values, chroma would record the same numbers in both cases.

Regarding peel and pulp colour index, correlation coefficients test proved that they had higher correlation than peel or pulp chroma. This view could be confirmed by L.S.D. ($P < 0.05$), where chroma pulp showed insignificant differences in the first season.

Concerning ripe stage or firmness by hand, results showed that its correlation with TSS and peel colour parameters was equal or slightly higher than that of instrumental methods (especially texture analyzer, 0.3 cm depth). Hence, ripe stage or firmness by hand (sensory evaluation) could be considered as a reliable and credible indicator for ripening progress of Ewais mango fruits (also for Zebda mango fruits) because of its ability to evaluate firmness till the end of ripening stages, while instrumental methods could not read firmness at final stages of ripening.

Zebda: a* value and hue of Zebda peel or pulp proved to be credible and reliable criteria, due to their correlation coefficients (high negative or positive correlation between them and ripening parameters, a/b, La/b of peel and pulp).

a/b and L a/b of peel and pulp showed the same trend, but a/b value in spite of its high correlation with other parameters, it had a narrower range of values. If we round the fraction value (hundredth) to the nearest (tenth), it will be a negligible number. This view could be confirmed by L.S.D. ($P < 0.05$), where a/b of peel showed insignificant differences in the first season. Thus, we can consider this character (a/b) as credible but not reliable. La/b can be used as a reliable and credible indicator for ripening progress of Zebda fruits

According to correlation coefficients test, it was impossible to rely on both b* value and chroma of Zebda peel or pulp, as insignificant correlation between b* values of peel and peel's a/b, chroma and colour index was observed. Insignificant correlation between b* values of pulp and all parameters except pulp chroma was observed. Insignificant correlation between peel chroma and L a/b and a/b of peel. Also, insignificant correlation between pulp chroma and all parameters except pulp b* and pulp colour index was monitored. This view could be confirmed by L.S.D. ($P < 0.05$), where both b* value and chroma pulp showed insignificant differences in the second season.

Due to the fact that Zebda mango fruits are uncoloured (green), there was insignificant correlation between peel colour index and TSS, total acidity, firmness and ripe stage. Accordingly, peel colour index is considered as an irreliable and incredible indicator for ripening progress of Zebda mango fruits. On the contrary, high correlation coefficients were observed between pulp colour index and TSS, ripe stage, a* values and La/b. High negative correlation coefficients were observed between pulp colour index and hue, total acidity and firmness.

Results emphasized the benefit of sensory evaluation as an indispensable indicator for ripening progress of Zebda mango fruits.

Regarding a* values and hue, our results confirmed the previous studies by Sobeih and El-Helaly (2002) and by Sobeih and Hassan (2007), who stated that a* value could be used as a reliable indicator for maturity and ripening progress of Alphonso and Keitt mango fruits. Ayala-Silva *et al.* (2005) noted that the hue angle (*h*) was a good factor to assess changes of the characteristic colour in mango cultivars. They also added that lower *h* values indicated a redder colour, as exemplified by 'Tommy Atkins' cultivar. The importance of sensory evaluation as a reliable method for determining fruit firmness was confirmed and corresponded with results obtained by Polderdijk *et al.* (2000), who mentioned that the best applicable method for measuring firmness of mango (measured a non-destructive acoustic, mechanically and manually according to a sensoric scale) proved to be the manual method.

REFERENCES

Abbott J. and Harker R. (2000). Texture Produce Quality and Safety. Beltsville, Maryland : Laboratory, USDA, ARS, P: 1-19.

Abbott, J.A.; R. Lu; B.L. Upchurch and R.L. Stroshine (1997). Technologies for nondestructive quality evaluation of fruits and vegetables. Hort. Rev., 20:1-120.

Araiza, E; T. Osuna; J. Siller; L. Contreras and E. Sanchez (2005). Post-harvest quality and shelf-life of mango cultivars grown at Sinaloa, Mexico. Acta-Horticulturae 682, (2): 1275-1279.

Association of Official Agricultural Chemists (A.O.A.C) (1990). Official Methods of Analysis. Benjamin Frankline Station, Washington 4. D.C., USA.

Ayala-Silva, T.; R.J.S. Chnell; A.W. Meerow; M. Winterstein; C. Cervantes and J.S. Brown (2005). Determination of colour and fruit traits of half-sib families of mango (*Mangifera indica* L.). Proc. Fla. State Hort. Soc., 118:253-257.

Brinson, K.; P.M. Dey; M.A. John and J.B. Pridham (1988). Post harvest changes in *Mangifera indica* mesocarp cell walls and cytoplasmic polysaccharides. Phytochemistry, 27: 719-723.

Campbell, C.W. and R. Campbell (2002). The 'Lancetilla Mango'. Proc. Interamer. Soc. Trop. Hort. 46:35-36.

De Mann, J. M. (1999). Principles of Food Science. Aspen Publications: Maryland.

El-Bassiouny, R.E.I. (2003). Differential response of mango fruit to post-harvest applications of modified atmosphere packaging (MAP) and 1-Methylcyclopropene (1-MCP). J. Agric. Sci. Mansoura Univ., 28 (4): 2595 – 2615.

El-Oraby, S.; A.M. Hassan and S.A. Fawaz (2004). Effect of low temperature and some supplemental treatments on the potential storage life of Fagri Klan mango fruits. Egypt. J. Appl. Sci; 19 (8): 343-361.

Gowda, I.N. and A.G. Huddar (2001). Studies on ripening changes in mango (*Mangifera indica* L.) fruits. J. Food Sci. Technol., 38(2): 135-137.

Hidalgo, M.; J. de la Cruz; K.L. Parkin and H.S. Garcia (1997). Refrigerated storage and chilling injury development of Manila mangoes (*Mangifera indica* L.). Acta-Horticulturae, 455: 718-725

Jacobi, K.K. and J.E. Giles (1997). Quality of 'Kensington' mango (*Mangifera indica* Linn.) fruit following combined vapour heat disinfestations and hot water disease control treatments. Postharvest Biology and Technology, 12 (3): 285-292.

Jha, S.N.; S. Chopra and A.R.P. Kingsly (2007). Modeling of colour values for nondestructive evaluation of maturity of mango. J. of Food Engin., 78(1): 22-26.

Kader, A.A. (1992). Postharvest Technology of Horticultural Crops, 2nd ed. University of California Division of Agric. and Natural Resources, Publ., p. 3311.

Kajuna, S.; W.K. Bilanski and G.S. Mittal (1995). Colour control in bananas and plantains in storage. Harvest and Post-harvest Technologies for Fresh Fruits and Vegetables, 601-608.

Kumar, S.P.; R.N. Roy; Singh and B.P. Jain (1999). Effect of ripening materials on the quality and storage of mango (*Mangifera indica*, L.). J. of Res. Birsa Agric. Univ., 8: 1, 33-73.

Lizada, C. (1993). Mango. In: Seymour, G.B. Taylor, J.E. and Tucker, G.A. (eds) Biochemistry of fruit ripening. Chapman and Hall, London, pp 255-271.

Lizada, M.C. (1991). Postharvest physiology of the mango-a review. Acta Hort. 291: 437-453.

Manzano, J.E., Y. Perez and E. Rojas (1997). Coating waxes on Haden mango fruits (*Mangifera indica* L.) cultivar for export. Acta Hort., 455: 738-746.

McGuire, R.G. (1992). Reporting of objective colour measurements. Hort-science, 27(12): 1254-1255.

Miller, W.R.; R.E. McDonald and J.L. Sharp (1991). Quality changes during storage and ripening of “Tommy Atkins” mangos treated with heated forced air. HortScience, 26 (4):359-307.

Mitcham, B.; M. Cantwell and A. Kader (1996). Methods for Determining Quality of Fresh Commodities. Perishables Handling Newsletter Issue No. 85 Page 1-5.

Nakasone, H.Y. and R.E. Paul (1998). Tropical Fruits. CAB International, UK.

Opara, L.U.; H.X. Nguyen and Levanto (2000). Postharvest technology for Vietnamese Buoi mango. Quality Assurance in Agricultural Produce. ACIAR Proceedings, 100: 633-638.

Ortega-Zaleta, D. and E.M. Yahia (2000). Tolerance and quality of mango fruit exposed to controlled atmospheres at high temperatures. Post-harvest Biology and Technology, 20(2): 195-201.

Polderdijk, J.J.; R.M. Kho; A.P. Kruif and Y. Carmi (2000). Firmness of mangoes (*Mangifera indica* L.) measured acoustically, mechanically and manually. Acta-Horticulturae, 509: 861-865.

Rathore, H.; T. Masud; S. Sammi and A. H. Soomro (2007). Effect of storage on physico-chemical composition and sensory properties of mango (*Mangifera indica* L.) variety Dosehari. Pakistan J. of Nutr., 6 (2): 143-148.

Sergent, E.; B. Schaffer; S.P. Lara and L.E. Willis (1993). Effect of ethephon on mango (*Mangifera indica* L.) fruit quality. Acta-Horticulturae, 341: 510-517.

Shivashankara, K.S.;S. Isobe; M.I. Al-Haq; M. Takenaka and T. Shiina (2004). Fruit antioxidant activity, ascorbic acid, total phenol, quercetin, and carotene of Irwin mango fruits stored at low temperature after high electric field pretreatment. J. Agric. Food Chem., 52 (5): 1281-1286.

Snedecor, G. and W.G. Cochran (1990). Statistical Methods. 7th Ed. The Iowa State Univ. Press Ames, Iowa, USA, P. 593.

Sobeih, M.E. and A.A. El-Helaly (2002). Storability, ripening behaviour and physiological disorder of Alphonso mango fruits in relation to maturity stage. J. Agric. Sci. Mansoura Univ., 27 (12): 8233-8244.

Sobieh, M. and G.F. Hassan (2007). Possibility of determining maturity stages according to Float/Sink Phenomenon and Effect of Ethylene Absorbent on Extending Storage Life and keeping quality of Keitt mango fruits. Minufiya J. Agric. Res., 32 (6): 1719 – 1743.

Ueda, M.; K. Sasaki; N. Utsunomiya and Y. Shimabayashi (2001). Changes in properties during Maturation and Ripening of 'Chiin Hwang No.1' Mango Fruit Cultivated in a Plastic greenhouse. Food Sci. Technol. Res., 7 (3), 207–213, 2001

Valero, C.; C.H. Crisosto and D. Slaughter (2007). Relationship between non-destructive firmness measurements and commercially important ripening fruit stages for peaches, nectarines and plums. Post-harvest Biology and Technology, 44: 248–253.

Weichmann, J. (1987). Post Harvest Physiology of Vegetables. Marcel Bekker, Inc, New York, P: 145.

Wen-Qin; Ma-Rong Chao; Dong-Qiao and Xin-Yao (2006). Studies on post-harvest physiology and the storage technology of mango (*Mangifera indica* L.). J. of Food Process. Preserv., 30(6): 670-683.

Yeshitela, T.; P.J. Robbertse and P.J.C. Stassen (2003). The impact of panicle and shoot pruning on inflorescence and yield related developments in some mango cultivars. J. Appl. Hort.,5(2):69-75.

Zambrano, J. and W. Materano (1998). Effects of heat treatment on post-harvest quality of mango fruits. Tropical Agric., 75(4): 484-487.

مصداقية نتائج تحليل جودة الثمار تبعا لاختلاف طرق تقدير اللون والصلابة

محمود السيد صبيح[1] ، أميرة عبد الحميد الهلالي[2] و فاطمة عصمت إبراهيم[1]

1- معهد بحوث البساتين – مركز البحوث الزراعية - جيزة

2- محطة بحوث البساتين بالصباحية الإسكندرية – معهد بحوث البساتين

حصدت ثمار مانجو خضراء (صنفي عويس وزبدة) في مرحلة اكتمال نمو مناسبة. أُجريت عملية إنضاج للثمار بواسطة غاز الأسيتيلين ، وتم تخزينها لمدة 8 أيام في درجة حرارة 23م ± 1 ونسبة رطوبة 85% ± 2 (وتم تحليلها كل يومين) ، أو خزنت الثمار لمدة 3 أسابيع على درجة 14 ، 18 م ونسبة رطوبة 85% ± 2 (تم تحليلها أسبوعيا) ، وذلك لتقييم مصداقية نتائج تحليل جودة الثمار تبعا لاختلاف طرق تقدير اللون والصلابة. تم فحص صفات ثمار المانجو من صنفي العويس والزبدة عن طريق تحليل كل من: لون القشرة واللب ، والمواد الصلبة الذائبة الكلية ، والحموضة ، والصلابة (سواء آليا أو يدويا). وقد أثبتت قيم a* ، La/b ، hue الخاصة بتدرج اللون مصداقيتها كمعيار يمكن الاعتماد عليه نظرا لإرتفاع درجة الارتباط التي تتميز بها (سواء كان هذا الارتباط سالبا أو موجبا فيما بينها ، أو بينها وبين مظاهر النضج الخاصة بالقشرة واللب). كما أظهر اختبار معامل الارتباط أنه لا يمكن الاعتماد على قيمة b أو على الـ chroma الخاصين بكل من القشرة واللب. إلا أنه من الممكن الاعتماد على اختبار الصلابة يدويا (والتقييم الحسي) واعتباره مؤشرا ذو مصداقية لتحديد مراحل نضج ثمار المانجو صنفي عويس وزبدة ، وذلك لقدرته على تقييم مدى صلابة الثمار حتى آخر مراحل النضج. بينما أثبتت الطريقة الآلية عدم القدرة على إنجاز المهمة نفسها في مراحل النضج المتأخرة أو قبلها مباشرة. وعلى ذلك فقد أكدت النتائج أهمية اختبار الصلابة يدويا واعتباره مؤشرا لا غنى عنه في تحديد مراحل نضج ثمار المانجو.

2091
2092
2093
2094
2095
2096
2097
2098
2099
2100
2101
2102
2103
2104
2105
2106
2107
2108
2109

Sobeih, M. E. et al.

Sobeih, M. E. et al.
Sobeih, M. E. et al.
Sobeih, M. E. et al.
Sobeih, M. E. et al.
Sobeih, M. E. et al.
Sobeih, M. E. et al.
Sobeih, M. E. et al.
Sobeih, M. E. et al.
Sobeih, M. E. et al.
Sobeih, M. E. et al.
Sobeih, M. E. et al.
Sobeih, M. E. et al.
Sobeih, M. E. et al.
Sobeih, M. E. et al.
Sobeih, M. E. et al.
Sobeih, M. E. et al.
Sobeih, M. E. et al.
Sobeih, M. E. et al.
Sobeih, M. E. et al.
Sobeih, M. E. et al.