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Physiological and Chemical Changes During Harvest Maturity in Peach Cultivars

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Experiments were conducted in 2002 and 2003 with 'J.H. Hale', 'Loring' and 'Dixigem' peaches. The optimum picking period for long-term shelf life corresponds to the period at which the respiratory activity of fruits is minimum or slightly late in climacteric fruits. However, slightly late period is the more reliable date for harvesting. Respiration rates were found 26.59 and 29.40 for J.H. Hale, 35.19 and 39.95 for Loring and 35.77 mL CO_2 (kg h) for Dixigem (2002 year) in two years. On the other hand, at the maturing date, several chemical and physical changes were also observed which are suitable for optimum harvest criterion. The criteria like ground colour, flesh colour, flesh firmness, TSS, maturity ratio and sensory analyses score were observed for all cultivars.

Key Words: Peach, Maturity, Respiration rate, Physiological and chemical changes.

INTRODUCTION

Ripeness at harvest is one of the primary factors affecting peach quality and composition. Climacteric fruits like peach picked at maximum respiration rates are fully ripened and have a superior organoleptic quality as has been reported by Kader[1] and Kaushal and Sharma[2]. Unfortunately, the shelf life (or storage) potential of these fruits is limited. Therefore, fruits are usually picked as matured but unripe as reported by Wills *et al.*[3] Fruits that are picked prematurely are likely to be small, poor coloured and will not give a full taste palette. In addition to this, the risk of developing different disorders like superficial scald or other disorder, is more in this situation. Fruits that are picked too late, are soft and become mealy prior to subsequent marketing. Hence these fruits are more susceptible to internal breakdown. Because of the large economic impact for growers, this optimum harvest period should be predicted as accurately as possible. This optimum picking period for long-term shelf life corresponds to the period at which the respiratory activity of fruits is minimum or slightly late in climacteric fruits. But, slightly late period is more reliable. This period of decrease in respiration is known as maturing and the

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commencement of the respiratory climacteric coincides approximately with the attainment of maximum fruit size[4, 5].

The prediction of the optimum harvest period is based on changes of several chemical and physical properties before harvest[6]. The primary fruit characteristics measured to describe readiness for harvest are: firmness, colour, stage of starch transition, components of taste (*e.g.*, sugar content, acidity), aroma (*e.g.*, esters and alcohols) and ethylene production[2].

The objective of this study is to determine the harvesting date by evaluating the respiration rate and to serve some practical measurements which can be used to lead as harvest criteria for growers.

EXPERIMENTAL

Plant Material: The fruits of 'J.H. Hale', 'Loring' and 'Dixigem (alone 2002 year)' peach varieties were collected weekly at the beginning that is approximately 2 months before harvest, and than after at 2 or 3 d intervals. Sixteen peach trees were carefully hand harvested for the above mentioned characteristics during the 2002 and 2003 years. Fruits were collected from Fruit Production Center, Tokat, Turkey. These are standard varieties being commonly grown in Tokat region.

Respiration Measuremtent: Fruit weight and volume were firstly evaluated for respiration rate of these fruits. These fruits were put into 1 L glass jars at early stages and 3 L glass jars at later stages and theneafter closed tightly. Measurement was done with a gas analysis equipment (GASPACE 2 model, Synthech Instruments, Oxfordside, OX, 3XA, England). After this the jars were kept for 5 h at room temperature (about 23–25°C). This equipment measures CO_2 under infrared light and O_2 with a zirconium probe in an oven which is replaced in the equipment and heats up to 650°C. CO_2 amounts were determined and then converted to respiration rate as mL CO_2/kg h[7, 8].

Colour Measurement: Skin ground colour and flesh colour were measured with a hand-held tristimulus reflectance (Minolta CR-300, Minolta Corporation, Osaka, Japan). 6 apples were replicated three times and then used for analysis. Colour was recorded using CIE-$L^*a^*b^*$ uniform colour space (-Lab), where L^* indicates lightness, a^* indicates chromaticity on a green (–) to red (+) axis and b^* chromaticity on a blue (–) to yallow (+) axis. Numerical values of a^* and b^* were converted to hue angle ($H° = \tan^{-1} b^*/a^*$) and chroma [Chroma = $(a^{*2} + b^{*2})^{1/2}$][9]. The a^* value is a^* measurement of greenness which is highly correlated with colour changes of fruit flesh and skin ground colour[10]. The H° is a colour wheel of 360°, with 0, 90°, 180° and 270° representing the hues red-purple and yellow colours respectively while chroma is the intensity or purity of the hue.

Titratable acidity (TA) and pH: Aliquots of 5–10 mg apple juice from 10 apple fruits were diluted with 40–50 mL of boiled water. Prepared juice was titrated with 0.1 N NaOH, up to pH 8.1. This potentiometer titration was performed with a pH combined electrode HI 2031 B/HI 2020 S (Hanna Instruments, Srl, V. de delle Industrie 12 35010 Ronchi di Villafranca (PD), Italy). The results were calculated as a percentage of malic acid [(mL NaOH × 0.1 N/weight of sample titrated) × 0.067 × 100].

The pH was measured in the non-diluted juice of the apple fruits, using a pH-meter (Hanna Instruments, Srl, V. de delle Industrie 12 35010 Ronchi di Villafranca (PD), Italy) being standardized to pH 2 and pH 7, having xerolyte electrode HI 2031B/HI 2020 S.

Total soluble solid (TSS): The TSS of the non-diluted fruit juice was determined at 20°C with a hand held refractometer (Hand Sugar Refractometer, model WYT-1). Results were expressed in terms of fresh weight (%).

Flesh firmness: The flesh firmness of fruit in the discrete measurement lots was evaluated manually using a drill stand-mounted Effegi penetrometer fitted with a 7.9 mm-diameter probe[11]. The penetrometer was calibrated using a top-loading balance. Two disks (*ca.* 2.5 cm in diameter) of skin tissue were removed, one from the most highly coloured side of the fruit and second from the opposite surface. The penetrometer probe was pressed into the tissue to a depth of 8 to 9 mm in a single smooth motion requiring *ca.* 1 to 2 s. Dates were recorded in libre (lb).

Maturity ratio (TSS/TA): The maturity ratio was measured as the soluble solid content (%)/titratable acidity (%).

Sensory analysis: A jury of 10 experts in this field made the sensory analysis as recommended by Stevens and Albright[12]. A 5-point hedonic scale was used: (1) dislike extremely; (3) either like or dislike and (5) like extremely. Each panelist was asked to note three main components of apple quality: colour, firmness and flavour together with overall fruit quality in terms of degree of liking each sample.

RESULTS AND DISCUSSION

Fruit maturity monitoring began on 7th of May in first year and on 10th of May in second year, completed on 29th of August and 12th of September in both years for all varieties. The major harvest parameters like respiration rate, TSS, pH, flesh firmness, maturity ratio (TSS/TA) and sensory analysis are given in Table-1; ground colour and flesh colour are given in Table-2.

TABLE-1
PHYSIOLOGICAL AND CHEMICAL CHANGES DURING HARVEST MATURITY IN THREE PEACH CULTIVARS

Cultivars	Year	Respiration rate (mL CO_2/kg h)	TA (%)	pH	TSS (%)	Flesh firmness (lb)	Maturity ratio	Sensory analysis
J.H. Hale	2002	26.59	1.09	4.11	10.83	11.00	9.98	4.4
	2003	29.40	0.63	4.48	12.83	12.00	20.53	4.2
Loring	2002	35.19	0.76	4.21	10.00	12.00	13.18	4.6
	2003	39.95	0.68	4.35	10.75	13.41	16.36	4.4
Dixigem	2002	35.77	0.55	4.30	7.50	14.00	13.64	3.6
	2003	—	—	—	—	—	—	—

This optimum picking period for long-term shelf life corresponds to the period at which the respiration activity of fruits is minumum or slightly late in climacteric fruits. But, slightly late period is more reliable. This period of decrease in

respiration is known as maturing. The commencement of the respiration climacteric coincides approximately with the attainment of maximum fruit size[4, 13]. Respiration rates were found to be 26.59 and 29.40 for J.H. Hale, 35.19 and 39.95 for Loring, 35.77 (in 2002) mL CO_2/kg h for Dixigem at this period in 2002 and 2003 years, respectively.

TABLE-2
COLOUR CHANGES DURING HARVEST MATURITY IN THREE APPLE CULTIVARS

Cultivars	Year	Ground colour			Flesh colour		
		L^*	a^*	b^*	L^*	a^*	b^*
J.H. Hale	2002	+71.93	–2.26	+50.05	76.76	–3.57	+55.47
	2003	+70.39	+13.37	+50.60	77.05	+7.88	+50.71
Loring	2002	+69.83	–6.78	+46.24	76.66	–1.66	+56.62
	2003	+72.79	+8.39	+45.99	77.03	+4.21	+52.70
Dixigem	2002	+69.76	+4.15	+47.27	75.86	–6.04	+54.30
	2003	—	—	—	—	—	—

Severe colour changes did not occur during the initial fruit development. All cultivars showed a slow increase in L^* values and regular decrease in a^*. In order to harvest peach correctly, people must be familiar with the term of ground colour. In most of the cultivars the peach skin would be changed to yellow[14]. Especially, a^* indicates chromaticity on a green (–) to red (+) axis. These findings suggest that chlorophyll fluorescence might be used to detect difference in maturity, ripeness or senescence of peach fruit[6].

The ground colour and flesh colour were given as (a^*) degree which are, at maturity date, for J.H. Hale –2.26 and –3.57 in 2002, 13.37 and 7.88 in 2003, for Loring –6.78 and –1.66 in 2002, 8.39 and 4.21 in 2003, for Dixigem 4.15 and –6.04 in 2002, respectively (Table-2).

A trend of increase in acidity and pH was not observed at maturity. However, these changes are not significant probably due to the effect of the buffering capacity of apple tissue. This stability of pH may have several positive implications like low activity of polyphenoloxidases, because in this range a variation in pH value would certainly imply a negative change in flavour[15].

Soluble solid (sugar) content increased with maturation. Usually this reaches to its maximum value when fruit is fully ripened although sugar content alone is not a good index of maturity[16]. The total soluble solid (TSS) contents of three cultivars evaluated were 10.83 and 12.88% for J.H. Hale, 10.00 and 10.75% for Loring and 7.50% for Dixigem (2002 year) in 2002 and 2003 years, respectively. These results are in agreement with the findings of Kaska and Kuden[8] and Crisosta and Kader[17]. These workers found 11.60% for J.H. Hale and 11.00% of TSS for most of the commercial peach varieties, respectively. The maturity ratio of 9.98 and 20.53 for J.H. Hale, 13.18 and 16.36 for Loring, 13.64 for Dixigem (2002 year) were also obtained in our findings. Flesh firmness ranged between 11 lb (for J.H. Hale in 2002 year) to 14 lb (for Dixigem in 2002 year) at maturity date.

The sensory analysis results are 4.4 and 4.2 for J.H. Hale, 4.6 and 4.4 for Loring, 3.6 for Dixigem (2002 year) in 2002 and 2003 years, respectively.

For all three varieties, the last week of August and the first week of September was the maturity date. The results of respiration rate obtained at maturing date are similar due to the results of Panova and Rakitska[18]. These workers reported respiration rates of 27 to 40 mL CO_2/kg h for Collins, Cardinal, Dixired, Redhaven and J.H. Hale cultivars. However, our results are lower than the findings of Crisosta and Kader[17], where 32 to 55 mL CO_2/kg h for some of the peach cultivars in 20°C is reported. Although the respiration rate of any variety may vary at the climacteric minimum, the date at this stage does not change too much from year to year for the same variety[19].

The pH of three peach varieties ranged between 4.11 to 4.48. J.H. Hale had lower pH values and higher titratable acidity than the others for the first year. J.H. Hale, on the other hand, had higher pH values and higher TA than Loring for the second year. However, the titratable acidity of two years was lower than the reports by Wills *et al.*[5] for J.H.Hale; these differences may be due to climatic conditions or varieties[20].

The total soluble solid and flesh firmness are also important harvest criteria and need no complex laboratory equipment. The varieties used in this research had similar content of total soluble solids. All varietes (except for Dixigem) contained more than 10.00% TSS. These results are in agreement with the results of Crisosta and Kader[17] and Kaska and Kuden[8]. However, our results for TSS increased with the maturity of fruits.

Flesh firmness varies depending on the variety of commercial harvests. However, according to the reports by Watada *et al.*[13], commercial peach varieties should be harvested at 12 to 16 pounds (*ca.* libre) of pressure for optimum storage. If the fruit is for immediate shipping or use (roadside operations), the lower firmness range is desirable. Our findings ranged between 11 to 14 lb in all varieties. These results were in agreement with the results of Watada *et al.*[13] for some of the growing commercial peach varieties. It is important to remember that firmness varies from season to season and factors other than maturity may affect firmness. For example, fruits on the outside of the tree canopy may have a higher pressure rating than fruits on the inside. Fruit size will also influence firmness readings, where the larger fruit is usually softer[22–24].

Conclusion

It is known that growers are aware of a number of factors that influence the maturity of peach. But when to harvest a particular peach variety is a problem to each grower. Similar researches carried out in different varieties may give different results. Ecological conditions also affect the harvest date. The harvest date may be a few days earlier if the temperature is hot and dry or it may be delayed if the temperature is cool and cloudy. So, it is necessary to evaluate the maturity date for each variety grown under different ecological conditions. Hence one standard method is not suitable for all the conditions.

The process of building models for harvesting date normally takes years to discover the pattern for a region. This study will continue for subsequent years. However, the results obtained from this study may be useful to the growers of

most regions. Maturing (harvest) date was determined for all varieties by respiration assesment. In later years, harvesting date can be suggested when soluble solids were at least 10% (for Dixigem 7.50%) and flesh firmness maximum 11–14 libre for all cultivars.

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