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Firmness and Sugar Content of Shangfen Peach

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Summary

Knowledge of the flesh firmness and sugar content of fruit is needed to grade or process peach fruit. The objectives of this study were to determine distribution of flesh firmness and sugar content in a Chinese peach cultivar. There were significant differences for firmness and sugar content in fruit 'latitude' and 'longitude'. Firmness and sugar content of samples from the suture area differed from those of cheek. Firmness and sugar content vary significantly with ripeness, also. Firmness decreased with increase of sugar content for ripe peach, but increased with increase of sugar content for a peach of the same picks.

Key words. peach – firmness – sugar content – anistropic

Introduction

Knowledge of the physical properties and the sugar content of fruit flesh and intact fruit is needed to grade or process peach fruits. Owing to the complex structure of fruits, the physical properties (e. g. firmness measurement) and sugar content may be influenced by factors such as shape, density, and variation of mechanical properties within the fruits as well as the positions of the sensor and input signal transducer.

In past decades, acidity, sugar and soluble solids content (SSC) of fruits had been studied extensively without considering anisotropic differences in fruit. For example, BASHIR et al. (2003) find that total soluble solids (TSS) and total sugars increased in pulp and peel of both guava types with decrease in flesh firmness (guava). Reducing sugars and titratable acidity increased up to the full-ripe stage and then decreased. Ascorbic acid and phenolic compounds decreased continuously during ripening of the two types. JEROEN et al. (2000) found that a relationship between the reflectance spectra and the soluble solids content by means of the partial least squares technique. STURMA et al. (2003) investigated sugars and organic acids in two different stages of ripeness: the stage of technological ripeness and the stage of complete ripeness. Statistical differences among the fruits of the same cultivar and of different maturity stages were established in the contents of glucose, fructose, xylose, fumaric, and shikimic acids, but there were no statistical differences in the contents of sucrose and citric acid. The results of the analyses conducted during the research confirm that the chemical composition of strawberry fruits significantly varied among the genotype of the plant and on the stage of maturity of fruit.

Elastic, viseo-elastic properties of fruit and sugar content have been the subjects of intensive research (FINNEY 1971; DE BAERDEMAEKER and SEGERLIND 1976; PETRELL et al. 1980; MOHSENIN 1986; LU and PURI 1991; AVINOAM et al. 1999; LU and DIWAN 2002; STURM et al. 2003; WANG et al. 2004; WANG and LU 2004; GÓMEZ et al. 2005). These studies generally focused on characterizing some basic mechanical properties without considering the inhomogeneous and properties of fruit, also. Anisotropic mechanical properties were reported (ABBOTT and LU 1996; WANG 2003, 2004), but little detailed information is available on anisotropic differences of firmness and sugar content and relationship between two indices within fruit.

The objectives of this study were to: (1) determine the differences of firmness and sugar content to orientation and part within peach, and (2) analyse the relationship between firmness and sugar content.

Materials and Methods

Shangfen peaches (*Prunus persica* cv. 'Fen Yu') were hand harvested from the experimental orchard in the Department of Horticulture, Zhejiang University, in the morning of either 12 to 15, June (first pick-unripe), 25 to 31, June (second pick-ripe), or 5 to 7, July, 2003 (last pick-overripe). Extremely large and small peaches were rejected. Peaches were inspected to ensure that they were uniform, and undamaged. After inspection, experiments were conducted within 5 h after the peaches were picked.

Peaches were divided into three latitudinal parts, representing the top, middle and bottom part of the peach from the calyx (top) to the part near the "pedicel-attachement point" (bottom). Six longitudes, evenly spaced circumferentially, were chosen and respectively coded as orientation 1 (side of suture I), orientation 4 (side of suture II), orientation 2, 3, 5 and 6 (cheek, Fig. 1). Measurement locations of each orientation were respectively at the middle of three parts (top, middle and bottom). A total of eighteen points of each peach were measured for firmness and sugar content.

Firmness was measured based on the resistance of the fruit flesh by the Magness-Taylor technique to maximum force to pierce the peach while the puncturing depth was 10 mm. The fruit was supported in a cradle that consisted of a 65 mm diameter (about the same as the fruit). The M-T firmness was measured with a 5 mm diameter probe.

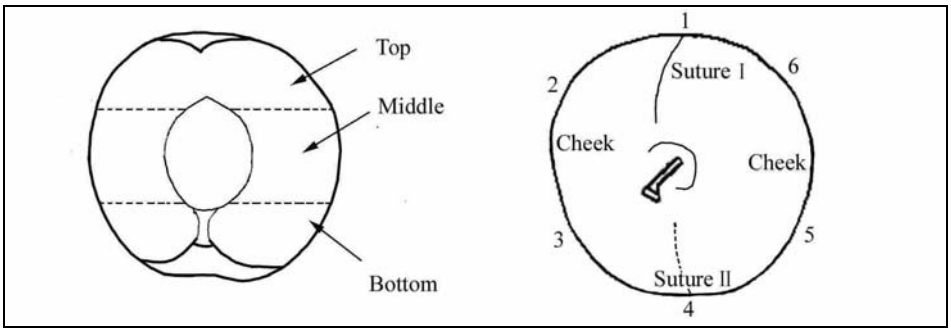


Fig. 1. Sample locations of the peach fruit.

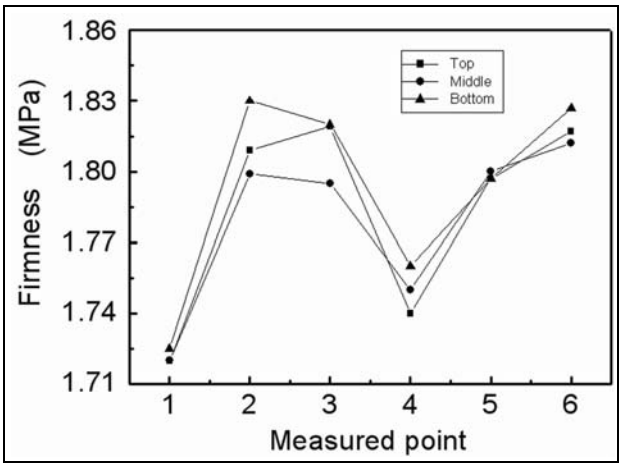


Fig. 2. Firmness of unripe Shangfen peach (The standard errors are less than 6.79 % of means).

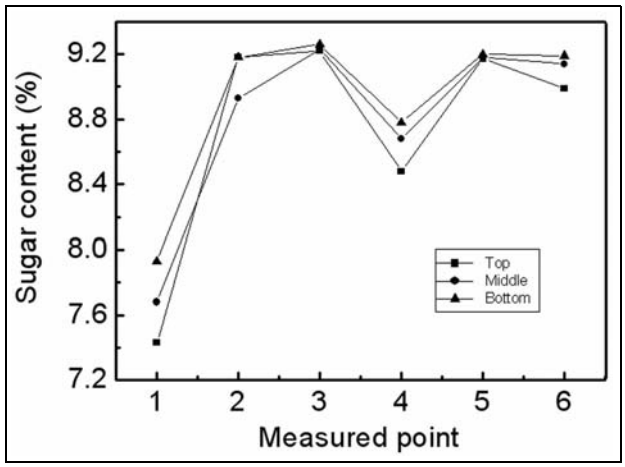


Fig. 3. Sugar content of unripe Shangfen peach (The standard errors are less than 8.59 % of means).

The measurement was carried out in an Universal Testing Machine (Model 5543 Single Column, Instron Corp., Canton MA. USA). The firmness was the ratio of maximum penetration force and cylindrical puncturing area (N m^{-2}).

The sugar analyses were carried out on a 0.5 cm^3 flesh using a high performance liquid chromatograph SP 8800 (Spectra Physics), with a NH_2 column, 5 l/ Spherisorb-Biochrom. Samples of 10 µL were injected at a flow rate of 2.0 ml min^{-1} using 80 % acetonitrile, 20 % water as eluent. The temperature of the column was 40 °C. The sugar content was detected by a refractive index detector HP 1047 (Hewlett Packard). The peaks were quantified by an external calibration method.

Firmness and sugar content of the same group peaches were measured sixteen times. The data in figures are means of replication tests, and the standard errors are less than 9.86 % of average values. To obtain the difference of firmness and sugar content affected by the factors such as the latitude, the longitude and ripeness, statistical analyses were performed using the SAS /STAT Procedure (SAS 1999).

Results and Discussion

Distribution of firmness and sugar content within a peach fruit

The distributions of firmness and sugar content within peach for three ripeness stages were shown in Fig. 2–7. Different "longitudinal" locations at the same latitude within peach showed the differences of two indices. Six longitudes (suture I, II, cheek 2, 3, 5, and 6) had an effect on firmness and sugar content ($p<0.01$). The two indices measured at point 2, 3, 5, and 6 did not greatly differ. Firmness and sugar content were lower in suture points (measured point 1, and 4, the ones in suture I were the least) and were higher in fruit's cheek for all three ripening stages.

Firmness and sugar content were greatly influenced by fruit latitude (top, middle and bottom) for ripe peach and over-ripe peach ($p<0.01$). This is consistent with ABBOTT et al. (1996) and WANG (2003, 2004) who found that the mechanical properties of apples and pears were affected by the fruit's latitude. For unripe peach, firmness and sugar content did not greatly differ at the same point in the three latitudes.

For ripe peach and over-ripe peach, firmness value and sugar content were higher in the bottom, and lower in the top. Hence, when Shangfen or other peach quality is to be evaluated for firmness and sugar content, the latitude should be considered.

It is presented that the lower the firmness, the lower the sugar content within a peach.

Effect of ripening stage on firmness and sugar content

Firmness values in the same parts of the peaches differed with the ripeness (Fig. 2, 4 and 6). The values of firmness were over 17 MPa in three parts for the unripe peaches, and were less than 5 MPa for the over-ripe peaches.

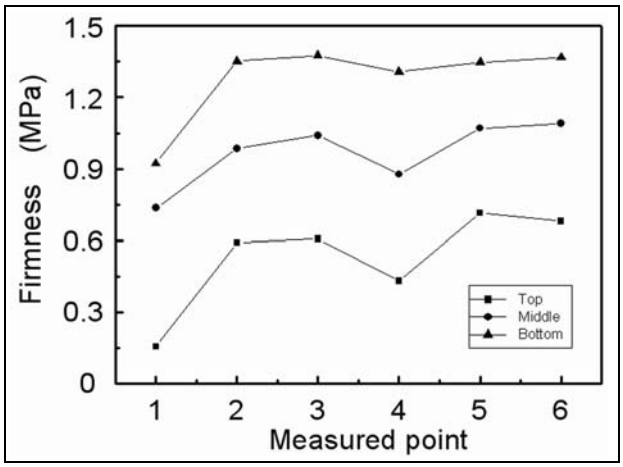


Fig. 4. Firmness of ripe Shangfen peach (The standard errors are less than 7.46 % of means).

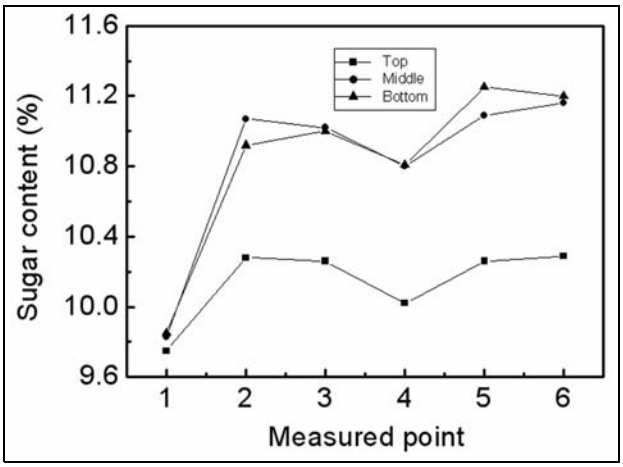


Fig. 5. Sugar content of ripe Shangfen peach (The standard errors are less than 9.27 % of means).

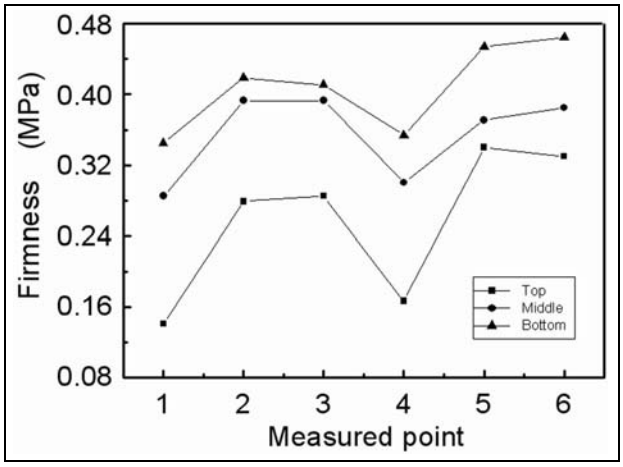


Fig. 6. Firmness of over-ripe Shangfen peach (The standard errors are less than 8.32 % of means).

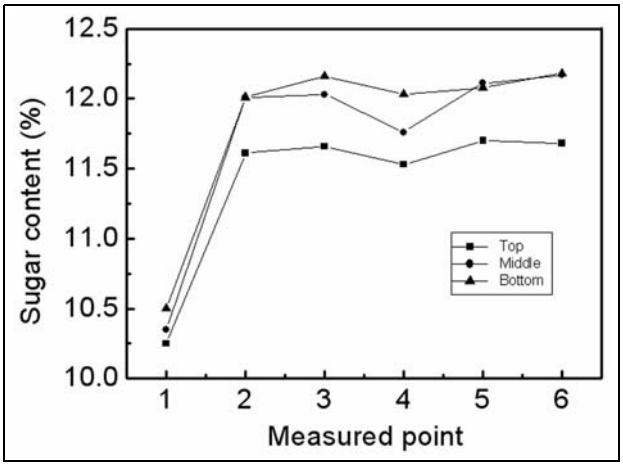


Fig. 7. Sugar content of over-ripe Shangfen peach (The standard errors are less than 9.86 % of means).

As shown in Fig. 3, 5 and 7, similar to the firmness, the sugar content differed with the ripeness. Sugar content at measured points was less than 9.3 % for the unripe peaches and over 10.2 % for the over-ripe peaches. The more ripe the fruit, the lower the firmness, and the higher the sugar content. The firmness decreased and the sugar content increased during growth process.

The maximal difference of the firmness value was 0.11 MPa between the highest and the lowest in the unripe peaches, 1.22 MPa in the ripe peaches and 0.324 MPa in the over-ripe peaches. The difference of firmness in peach increased during the growth process, but for over-ripe peach, the difference decrease. The maximal difference of the sugar content between the top and the bottom was 1.83 % for the unripe peaches, 1.53 % for the ripe peaches and 1.83 % for the over-ripe peaches. The maximal difference in sugar content varied less with the ripeness.

Comparison between squeezed peach juice and fresh fruit

Comparison of sugar content between part of locations and fruit juice (squeezed juice from the pear without shin and core) are shown in Table 1. The sugar content of fruit

Table 1. Comparison of sugar content of three parts of fresh peach fruit with that of freshly squeezed peach juice.

Factors	Average sugar content of measured point 2, 3, 5, and 6 (%)			Sugar content of fruit juice (%)
	Top	Middle	Bottom	
Unripe peach	9.11	9.14	9.24	9.14
Ripe peach	10.25	10.95	11.08	10.99
Over-ripe peach	11.66	12.08	12.20	12.10

juice was close to that of the cheek locations in the middle for three ripe peaches, and there was no significant difference ($p>0.05$) for two indices.

Based on the analyses, it is preferable to measure firmness and sugar content in the fruit's "equatorial cheek" to evaluate the peach quality.

Conclusions

(1) There were significant difference in firmness and sugar content with 'latitude' and 'longitude'. Both firmness and sugar content of Shangfen peach from the suture area differed from those of cheek.
(2) Firmness and sugar content vary significantly with ripeness. The ripeness had significant effect on two indices.
(3) Fruit firmness decreased with increase of sugar content for peach ripe process, but increased with increase of sugar content within a peach of the same picked-period.

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