The difference of sensory qualities of apple fruit among eight cultivated varieties

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Abstract. The differences of sensory qualities among 8 apple varieties were studied by the properties, including moisture content, color difference and texture using color difference meter and texture analyser. These three parameters had a significant effect on the sensory edible qualities of apple. The results showed that, there were great differences on fruit sensory qualities among 8 cultivated apple varieties. Water content of Ralls was the highest; the moisture contents of Orin and Indo were lower. Golden Delicious in color difference was clearly distinguished from other varieties. The hue angles of Golden Delicious, Orin and Indo all showed negative values, while other varieties showed positive values. The chromas of Golden Delicious and Indo were higher than others. In terms of texture, for Ralls, Wangshanhong, Orin and Indo, both fruit flesh hardness and peel hardness were higher, while the two indexes of Gloden Delicious were lower.

1. Introduction
Apples are one of the most widely grown fruits in the world [1], as well as one of the most frequently consumed fruits [2]. For fruits, moisture content is the index to evaluate firmness and freshness. Apple firmness is one of the most important characteristics of sensory quality [3], which is frequently used to determine their maturity and ripeness [4]. Color plays a major role in quality assessment of fruit significantly determining consumers' choice [5]. Thus, it is necessary to study the three parameters among apple varieties. In this work, the main sensory indexes, such as, moisture content, color and texture were evaluated and compared among eight apple varieties which were most widely cultivated in Western Liaoning Provence, China. This could provide some theoretical foundations for apple processing and preservation.

2. Materials and methods

2.1 Apple sample.
Mature apple fruits (Malus pumila) of 8 cultivars, “Ralls”, “Huafu”, “Jonagold”, “Wangshanhong”, “Hanfu”, “Orin”, “Golden Delicious” and “Indo” were hand-harvested from commercial maturity trees in Jinzhou, Liaoning Province, China, during the growing season of June 2017, and were transported to the laboratory of Bohai University on the intraday of sampling.

2.2 Moisture content.
Water content determination was done by drying the samples at 105℃ using drying oven until the
weight became constant [6]. Took three apples, every apple cut into pieces and took 4 square pieces of 2cm×2cm×2mm. The oven temperature was set as 105℃, the mass before drying was \( m_0 \), and the mass of drying to constant weight was \( m_1 \). The experimental samples were measured by three repetitions. The function of moisture content (MC) was as following:

\[
MC = \frac{m_0 - m_1}{m_0} \times 100\%
\]

(1)

2.3 Color difference.
The color difference of apple was determined using CR-400 chroma meter (Konica Minolta Sensing, Ink., Tokyo, Japan). Color was expressed as \( L^* \), \( a^* \), and \( b^* \), indicating luminosity, chromaticity on a green (−) to red (+) axis, and chromaticity on a blue (−) to yellow (+) axis, respectively [7]. Chroma \( [C^* = (a'^*+b'^*)^{1/2}] \) and hue angle \( [h^° = (\arctan b^*/a^*)] \) were calculated from \( a^* \) and \( b^* \) values [8]. Six parallel experiments were carried out in the sample. The total color difference (\( \Delta E^* \)) was calculated on the basis of the following formula:

\[
\Delta E^* = \sqrt{\Delta L^*} + (\Delta a^*)^2 + (\Delta b^*^2)
\]

(2)

2.4 Texture.
The texture of apple was measured using TA-XT-PLUS Texture Analyser (Stable Micro Systems). The apple samples with skin were cut into cubes of 1.5×1.5×2 cm for testing. The texture parameters were set as follows: P/2 probe, pretest velocity 1.00 mm/s, test speed 1.00 mm/s, post-test uplink velocity 1.00 mm/s, measuring distance 10 mm. The purpose of this test was to obtain the apple firmness of the peel and pulp. The experimental samples were measured by six repetitions.

2.5 Statistical analysis.
One-way ANOVA test by SPSS Statistics 20.0 was used to test significant differences (\( p < 0.05 \)) among eight varieties apple. Experimental dates were expressed as mean ± standard error (\( p < 0.05 \)).

3. Results and discussion

3.1 Difference on apple moisture content
The differences of moisture content among 8 varieties of apple were depicted in Figure 1. As shown in Figure 1, the moisture content of Ralls was the higher, while those of Indo and Orin were lower. The moisture contents in Jonagold and Huafu were also higher than 90%, and there was no significant difference between the two varieties.

![Figure 1](image.png)

Figure 1. The difference of water content among 8 varieties of apple. Different letter (a-e) meant significant difference (\( p < 0.05 \)). Data are the mean of triple replicates and vertical bars indicate ±SD.

3.2 Color difference
The results of color difference analysis of 8 varieties of apple were shown in Table 1. \( L^* \) can express
the level of luminosity on apple epidermis. The apple peel colors of Golden Delicious and Orin were much brighter than those of other varieties, and there showed a significant difference (p < 0.05). Compared with other varieties, the brightness of Ralls and Jonagold were lower. Low levels of luminosity indicated high levels of browning since darkness was related to browning [9].

The fruit ground colors of Ralls and Huafu were red-green. The fruit ground colors of Jonagold, Wangshanhong and Hanfu were red or with red stripes. Orin and Golden Decilious belonged to yellow-green color varieties. While the peel color of Indo was green-yellow. The index of a* was used to evaluate the change of peel chromaticity on a green to red axis [7]. Table 1 showed that most apple varieties were red, except Golden Delicious, Orin and Indo. There was no significant difference on a* among the first five varieties apple (p < 0.05). And there was also no significant difference between Golden Delicious and Orin (p < 0.05). The b* value was used to be a measurement of yellowness [7]. From Table 1, the b* value of green-yellow variety Indo and yellow-green varieties Orin and Golden Delicious were higher.

Table 1. Results of color difference analyses among 8 kinds of apples

| Apple Variety   | L*     | a*     | b*     | △E*       |
|-----------------|--------|--------|--------|-----------|
| Ralls           | 57.80±4.84d | 23.64±6.84a | 25.41±3.29c | 49.95±6.33ab |
| Huafu           | 60.93±6.24ad | 19.91±7.69a | 27.71±3.39d | 46.62±7.33b  |
| Jonagold        | 57.80±7.22d | 24.30±8.84a | 27.64±2.66d | 51.17±9.21a  |
| Wangshanhong    | 60.91±6.27ad | 19.87±7.68a | 27.35±3.03d | 46.38±7.57b  |
| Hanfu           | 61.61±4.15c | 19.93±5.29a | 29.48±2.60c | 46.56±4.96b  |
| Orin            | 84.15±1.11a | -10.70±0.61b | 30.31±0.74c | 25.17±1.22d  |
| Golden Delicious| 84.28±0.72a | -6.25±18.88b | 44.64±2.29a | 38.62±2.27c  |
| Indo            | 69.11±1.01b | -19.94±1.24c | 37.60±1.74b | 41.80±1.70c  |

Data were the means of 6 different fruits and vertical bars indicate ± SD. The different letters (a-e) indicate significant difference in the same column (p < 0.05).

Figure 2 showed the differences of hue angle (h°) and chroma (C*) of 8 varieties of apple. Hue angle was an important parameter to evaluate fruit color, and it could be used to describe the change of fruit quality. Figure 2 (A) showed that there was no significant difference on h° of Golden Delicious, Orin and Indo (p > 0.05), and the values of them were negative, while other varieties showed positive values. Chroma (C*) described chromaticity, and it was an indicator of color intensity and visual properties as associated with color [10]. With the saturation was higher, the color intensity was brighter, and chroma was higher. From Figure 2 (B), the chromas of Golden Delicious and Indo were higher.
Figure 2. Color difference of 8 apple varieties, (A) Hue angle (h°) and (B) Chroma (C*). Different letters (a-e) meant significant difference (p < 0.05). Data are the mean of 6 different fruits and vertical bars indicate ± SD.

3.3 The difference of texture characteristics

Texture was an important evaluation index for fruit sensory qualities. The results of texture characteristics of eight varieties of apple were described in Figure 3. From Figure 3, the firmness value of apple flesh was between 200 g and 400 g. The flesh hardness of Wangshanhong and Ralls were higher, and those of Golden Delicious and Jonagold were lower. There showed a medium flesh hardness on Huafu, Hanfu, Orin and Indo, and there was no significant difference among them (p > 0.05). As far as pericarp was concerned, the peel hardness of Ralls, Wangshanhong, Orin and Indo were higher than others, and peel hardness of Golden Delicious was the lowest. On the whole, for Ralls, Wangshanhong, Orin and Indo, both fruit flesh hardness and peel hardness were higher, while the two values of Golden Delicious were lower.

Figure 3. The difference of texture characteristics on 8 varieties of apple. Different lowercase letters (a-c) represented significant difference on flesh firmness (p < 0.05), and different uppercase letters (A-E) represented significant difference on peel hardness (p < 0.05).

4. Conclusions

There were great differences on moisture content, color difference and texture among 8 varieties of
apple. Water content of Ralls was the higher; the moisture contents of Orin and Indo were lower. Golden Delicious in color difference was clearly distinguished from other varieties. In terms of texture, for Ralls, Wangshanhong, Orin and Indo, both fruit flesh hardness and peel hardness were higher, while the two indexes of Golden Delicious were lower.

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References
[1] Schmutzer G R, Magdás A D, David L I, Moldovan Z 2014 Determination of the volatile components of apple juice using solid phase microextraction and gas chromatography–mass spectrometry[J] Analytical Letters vol 47, ed Taylor and Francis (London: Mortimer Street) pp 1683-1696
[2] Yi J Y, Zhou L Y, Bi J F, Wang P, Liu X, Wu X Y 2015 Influence of number of puffing times on physicochemical, color, texture, and microstructure of explosion puffing dried apple chips[J] Drying Technology vol 34, ed Taylor and Francis Group (University of Maine - Orono) pp 773-782
[3] DeEll J R, Khanizadeh S, Saad F, et al. 2001 Factors affecting apple fruit firmness-a review[J] Journal American Pomological Society vol 55, pp 8-27
[4] Konopacka D, Plolharski W J 2004 Effect of storage conditions on the relationship between apple firmness and texture acceptability[J] Postharvest Biol Technol vol 32, (Pomologiczna: Poland) pp 205-211
[5] Stintzing F C, Carle R 2004 Functional properties of anthocyanins and betalains in plants, food, and in human nutrition[J] Trends in Food Science & Technology vol 15, (Garbenstrasse:Germany) pp 19-38
[6] Meisami-asl E, Rafiee S 2009 Mathematical modeling of moisture content of apple slices (var. Golab) during drying[J] Pakistan Journal of Nutrition vol 8, pp 804-809
[7] Chen Z, Zhu C, Zhang Y, Niu D, Du J 2010 Effects of aqueous chlorine dioxide treatment on enzymatic browning and shelf-life of fresh-cut asparagus lettuce (Lactuca sativa L.)[J]. Postharvest Biol Technol vol 58, pp 232-238
[8] Holzwarth M, Korhummel S, Carle R, Kammerer DR 2012 Evaluation of the effects of different freezing and thawing methods on color, polyphenol and ascorbic acid retention in strawberries (Fragaria×ananassa Duch.)[J] Food research international vol 48, pp 241-248
[9] Martin-Diana A B, Rico D, Barry-Ryan C, Frias J M, Mulcahy J, Henenan G T M 2005 Calcium lactate washing treatments for salad-cut Iceberg lettuce: Effect of temperature and concentration on quality retention parameters[J] Food research international vol 38, pp 729-740
[10] Esti M, Cinquanta L, Sinesio F, Moneta E and Di Matteo M 2002 Physicochemical and sensory fruit characteristics of two sweet cherry cultivars after cool storage[J] Food Chemistry vol 76, pp 399-405