Bangladesh J. Bot. **48**(3): 901-906, 2019 (September) Special

COMPARATIVE ANALYSIS OF BASIC QUALITY OF PASSION FRUITS (*PASSIFLORA EDULIS* SIMS) IN GUANGXI, GUIZHOU AND FUJIAN,CHINA

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Keywords: Fruit mass, Passion fruits, Production areas, Pulp content, Shape index, Sweetness

Abstract

In the present study, the basic fruit quality indicators, including fruit mass, pulp content, fruit shape index, sweetness and pH of fresh passion fruits from three areas of China were determined. The results showed that with different areas and extended storage time, the values of the quality indicators and the appearance of the fruits changed drastically. The fruit skins gradually wrinkled, and lesions appeared on some of the fruit surfaces. The fruit mass, pulp mass and sweetness of all significantly reduced, whereas the pH increased. The average fruit shape index of the three groups were 1.09, 1.13 and 1.15, respectively. Sample 1 was round-shaped while sample 3 was more elliptical.In addition, the ratios of grade superior fruits from the three production areas were 65, 75 and 60%, respectively, and the ratio of grade I fruits were 35, 25 and 40%, respectively. Based on these basic indicators, it is concluded that the growth conditions had a certain effect on the sweetness and quality of passion fruits. Meanwhile, different growth conditions of passion fruit provide varieties of flavors, thus enriching the market diversification and satisfying various taste needs from a variety of consumers.

Introduction

Passiflora edulis Sims is a herbaceous climbing vine (Krosnick *et al.* 2013). It is originated from South America and is now extensively cultivated in tropical and subtropical areas (Souza *et al.* 2002, Silva *et al.* 2014). The fruit is also named as Passion fruit. In the People's Republic of China, it has been widely cultivated since 1980s and during the last three years, the planting area has reached 19996 ha. Essentially, the passion fruit is a berry and typically contains 250 black seeds. Each seed measures 2.4 mm in length and is surrounded by a membranous sac filled with pulpy juice (Silva *et al.* 2014). So, the primary edible part of a passion fruit is the pulp. The juice has a bright color of between lemon yellow and orange and accounts for more than 30% of the weight of a ripe fruit. The rich aroma of passion fruit integrates the aroma of guava, pineapple, mango and banana (Jordán *et al.* 2002, Fu *et al.* 2005, Janzantti and Monteiro 2017). Passion fruit is excellent in color, aroma, flavor and nutrition. It contains 17 amino acids and more than 160 beneficial ingredients such as vitamins and trace elements necessary for human health (Hugo *et al.* 1999, Zhang *et al.* 2017, Song *et al.* 2018) and thus is very popular in China.

In China, passion fruits are primarily cultivated in warm-wintered areas, such as Fujian, Guangdong, Yunnan, Guangxi and Taiwan (Krosnick *et al.* 2013, Zhang *et al.* 2017). The three major varieties are named as yellow-, purple- and purple-red passion fruits (Souza *et al.* 2002, Fu *et al.* 2005) The purple passion fruits have purplish-red skin color and green vines. They grow well at areas with cooler summers within elevation of 300 - 500 MSL, but not in areas like Pearl

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River Delta or south, where hot summer weather does prevail. The yellow passion fruits have strong adaptability. They produce large fruits with high yield, excellent quality and high juice content. Therefore, they are the major cultivated variety, but with poor cold tolerance. Some varieties are self-sterile and have to be pollinated by human intervention. For the growth, passion fruits prefer temperature above 0ºC having an average temperature of 20ºC. Grafting and cutting are the main means of propagation and usually the fruits could be harvested within four months (Fu *et al.* 2005, Li *et al.* 2011).

In passion fruit, the quality means fruit mass, fruit shape index, fruit firmness, soluble solids content, total acid content, soluble solids/acid ratio and sweetness (Fu *et al.* 2005, Tian *et al.* 2007, Jha*et al.* 2010). Passion fruits may have different taste and flavor due to their different planting environments. Hence, the research work was done to study the effect of location on the quality of the fruit.

Materials and Methods

The experiment was conducted having treatment as passion fruit sample 1: Beiliu of Guangxi Province, sample 2: Zhenfeng of Guizhou Province, sample 3: Longyan of Fujian Province, and three time points, time 1 : 4 days after harvest, time 2 : 8 days after harvest, and time 3 : 12 days after harvest. The varieties were purple red fruits.

In the present research, all the measurements for determining various masses of passion fruit were performed by using an electronic balance (YP1002, Shanghai Yueping). Calculation for measuring the pulp content was performed as follows: pulp mass = (fruit mass – skin mass). For determining the content of pulp and skin mass, a fruit knife was used to dissect one third of the fruit. A spoon was used to remove all the pulp, then the skin was rinsed, air dried and placed on the balance, and finally the stable weight was read in grams.

The fruit shape index was determined with an eight-inch SANTO 8010 mechanical vernier caliper.

The pH was measured with a PHB-3 pen type pH meter (Shanghai San xin). An Atago PAL-1 Refractometer was used forsweetness determination.The three test areas are all in south of China, and the weather at harvest seasons are mostly rainy and humid, but there are some differences in geographical location and temperature (Table 1).

Table 1. Location and temperature of the three test areas.

Area	Longitude	Latitude	Average lowest temperature (°C)	Average highest temperature (°C)
Beiliu, Guangxi	110.35	22.72	25.7	33.0
Zhenfeng, Guizhou	105.65	25.38	20.0	24.0
Longyan, Fujian	117.03	25.10	23.3	29.0

The fruit grade identification was made according to the Ministry of Agriculture of the People's Republic of China Passion fruit Grade Standards of NY/T 491-2002. The fruit transverse diameter was used to determine the grade of passion fruit. A transverse diameter of > = 5.5 cm is classified as superior grade. However, a transverse diameter between 4.5 and 5.5 cm has been considered as grade I. Passion fruits of grade II show a transverse diameter from 3.5 - 4.5 cm.

The one-way analysis of variance (ANOVA) was used to analyze both the data at time 1 for different samples and the data of one sample with respect to different test time points (Time 1, 2, and 3). F was the test statistics, p-value was the observed at significance level and F crit was the critical value.

Results and Discussion

The results revealed that quality of passion fruit changed with treatment variables significantly which is given parameter wise.

Fruit mass: The statistical analysis of the data was performed by using one-way ANOVA on the time 1 data of the three sample groups. ($F = 7.690048349$、$Fcrit = 3.354130829$). The results revealed a statistically significant difference ($p < 0.05$) between the three groups. The average value of each group was calculated. Sample 2 had a mass of 73.53 g, which was the highest. The masses of sample 1 and sample 3 were 62.11 and 69.15 g, respectively. Further analysis with one-way ANOVA on the three groups, regarding three time points, demonstrated no significant difference between time 1 and time 2 but the difference between time 1 and time 3 was statistically significant. The results showed that the fruit mass of all the three sample groups dropped significantly at time 3, which was approximately 77.83, 81.65 and 81.96%, respectively compared to those of time 1.

Pulp mass: Statistical analysis was used to obtain the pulp mass of the three groups at time 1. The one-way ANOVA exhibited statistically significant difference ($F = 3.367167$, $Fcrit = 3.354131$, $p < 0.05$) between the three groups. Further, the average value of each group was calculated, giving the highest mass of 36.14 g for sample 2, 31.15 g for sample 1 and 30.77 g for sample 3. Similarly, no significant difference was found in one-way ANOVA on the three groups regarding three time points. However, compared to Time 1, the pulp masses of Sample 1 and 2 both dropped by about 5 g at Time 3, the pulp mass of sample 3 decreased by about 3 g. The pulp mass of sample 1 decreased the most.

Pulp pH: The pH of the three groups at time 1, showing a significant difference ($F = 76.15663$, $F crit = 3.354131$, $p < 0.05$) between the three groups ($p < 0.05$). Further, the average pH of each group was calculated. sample 3 had the lowest acidic level, with a pH value of 3.14 and the pH values of Sample 1 and 2 were 2.87 and 3.08, respectively. Then one-way ANOVA was performed on the three groups regarding three time points, demonstrating a significant difference between time 1 and time 2, as well as between time 1 and Time 3 ($p < 0.05$). It can be seen from table 2 that the pH of the three groups increased with time. The pH values at time 2 were 3.11, 3.14 and 3.14, respectively. For Time 3, the pH values were 3.13, 3.41 and 3.41, respectively.

Pulp sweetness: The one-way ANOVA was performed on the sweetness of the three groups at time 1 and demonstrated statistically significant differences ($F = 38.13855$, $Fcrit = 3.354131$, $p < 0.05$) between the three groups. The average sweetness of sample 1 was 17.95 Brix, the sweetest one. The average sweetness of sample 2 and 3 were 17.67 and 16.49 Brix, respectively. Further one-way ANOVA was performed on the three groups regarding three time points, exhibiting a significant difference ($p < 0.05$) between time 1 and time 3. The sweetness of the three groups at Time 3 were 80.30, 88.40 and 95.27% of the sweetness at time 1. The result indicated a significant decrease in the sweetness for sample 1 and a lower overall sweetness of sample 3.

Fruit shape index: Since the skins had no wrinkles and the fruits were completely intact at time 1, the fruit shape index determination was performed at time 1. The fruit shape indexes of all the three groups were obtained for statistical analysis. The one-way ANOVA revealed significant differences ($F = 8.003499$, $F crit = 3.354131$, $p < 0.05$) between the three groups. Figure 1 shows

that the average fruit shape index of the three groups were 1.09, 1.13 and 1.15, respectively. Sample 1 was round-shaped while Sample 3 was more elliptical.

Table 2. Statistical result of three samples of passion fruit at three time points.

		Time 1	Time 2	Time 3
Fruit mass (g)	Sample 1	62.11	58.32	48.34
	Sample 2	72.53	70.03	60.04
	Sample 3	69.15	60.04	56.92
Pulp mass(g)	Sample 1	31.15	30.52	26.15
	Sample 2	36.14	35.21	31.24
	Sample 3	30.77	30.19	27.40
Pulp fruit mass ratio (%)	Sample 1	50.15	52.33	54.10
	Sample 2	49.83	50.28	52.03
	Sample 3	44.50	50.28	48.14
Pulp pH	Sample 1	2.87	3.11	3.13
	Sample 2	3.08	3.14	3.41
	Sample 3	3.14	3.33	3.41
Pulp sweetness (Brix)	Sample 1	17.95	17.62	14.41
	Sample 2	17.67	17.37	15.62
	Sample 3	16.49	16.22	15.71

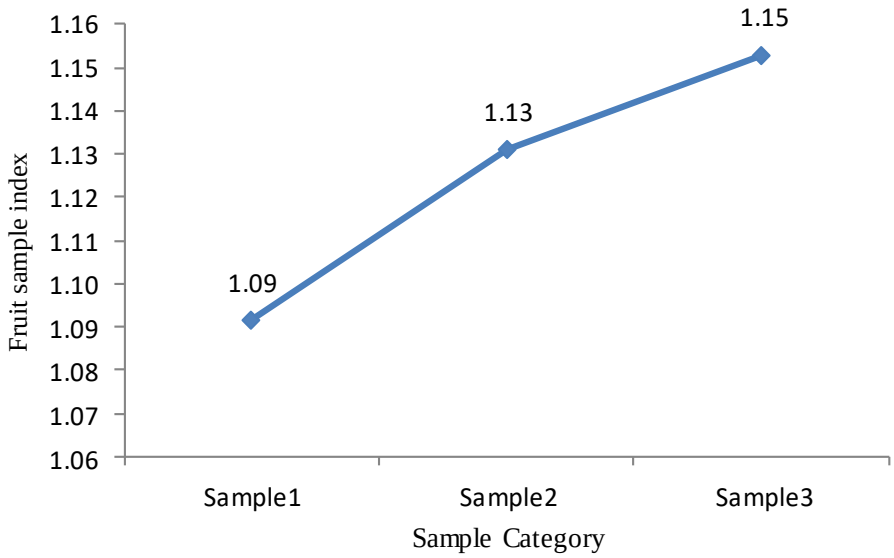

Fig. 1.Fruit shape index analysis of the three groups of samples.

The calculated grade standards of passion fruit have been plotted in (NYT491-2002) Fig. 2. The ratios of superior grade were 65, 75 and 60%, respectively. The ratios of gradeIfruits were 35, 25 and 40%, respectively. There were no fruits for grade IIor lower fruits (Fig. 2).

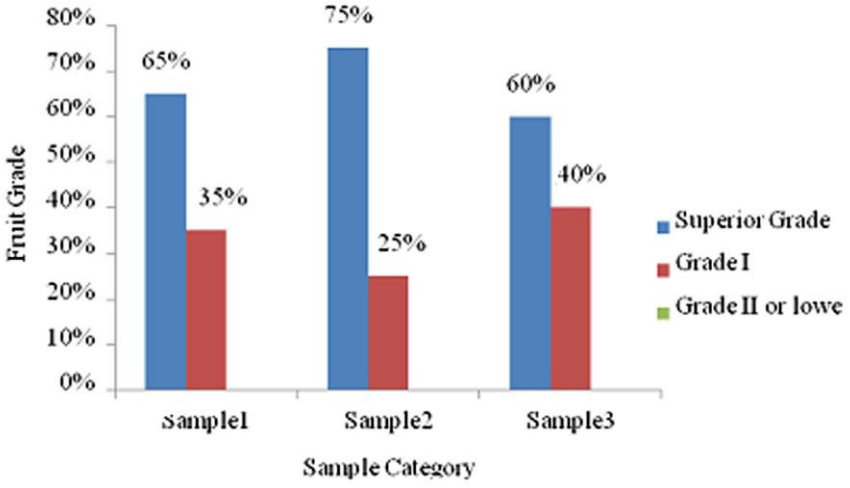

Fig. 2. Passion fruit grade of the three groups of samples.

The ratios of the grade superior fruits of all the three production areas were greater than 60%. These superior fruits can be sold as fresh fruits, and the sale price would generate revenues more than two folds compared to the cost. The grade I fruits may be sold as fresh fruits or processed fruits, with a sales price slightly lower than that of the grade superior fruits (Janzantti *et al.* 2017). At the same time, a higher ratio of grade superior also indicates better cultivation skills of the planting area.

With the prolongation of storage, the skin wrinkles and even mold develops. All these decrease the fruit and pulp masses and sweetness (Fu *et al.* 2005). Therefore, it is suggested to eat them within ten days of harvest. Although, the pH would increase and adjust the ratio of sugar to acid to compensate the taste (Tian *et al.* 2007, Zhang *et al.* 2017). After all, the organic matter and water are consumed. But, attack by molds and fungi to the passion fruits make them totally unfavorable for eating (Song *et al.* 2018). In addition, the storage place in this study is located in the Hainan Province, China. This area has a high humidity and a high temperature which is extremely conducive to the growth of bacteria and fungi. Therefore, the storage period may be extended for a few days at dry and lower temperature areas only.

It was found that climatic conditions had a certain effect on the fruit sweetness as well as on the accumulation of sugar. The growth cycle of *P. edulis* was longer at low temperature production areas, resulting in heavier fruits. While the passion fruits produced in areas with large temperature changes, have stronger sweetness, consistent with the basic laws of fruit tree growth and development. In this study, the sweetness of passion fruit was 16-18 Brix which was significantly higher than the sweetness of other common fruits. For instance, the sweetness of apple, kiwi, banana, grape and watermelon were 6 - 9, > 6, 10 - 12, 7 - 12 and 7 - 10 Brix, respectively. These were the main reasons why passion fruits were so deeply loved and chosen by the market and the people.

Acknowledgements

Thanks for the support of Key research and development project of Hainan province (No.20090960), and Central Public-interest Scientific Institution Basal Research Fund for Chinese Academy of Tropical Agricultural Sciences (No. 1630092019007)，Guizhou Lurong Huinong Science and Technology Development co., LTD., and Yuyu Gong, Xiuli Fu, Shengjun Cai and Yongsheng Wang.

References

Fu XP, Li JP, Zhou Y, Ying YB, Xie LJ, Niu XY, Yan ZK and Yu HY 2009. Determination of soluble solid content and acidity of loquats based on FT-NIR spectroscopy. J. Zhejiang Univ-Sc. B.**2**: 120-125

Fu YL, Kang XN and Liu TZ 2005. Nutritional health value and pollution-free cultivation techniques of passion fruit.Hebei Fruits**3**: 35.

Hugo, NK, Marco SM, and Muñoz AM 1999.Effect of 3 storage temperatures on the quality of kiwi fruit pulp concentrated at a reduced pressure. Archivos Latinoamericanos De Nutrición, 49(4): 351.

Janzantti NS and Monteiro M 2017. HS-GC-MS-O analysis and sensory acceptance of passion fruit during maturation. J. Food. Sci. Technol.**8**: 2594-2601.

Jha SN,and Garg R 2010. Non-destructive prediction of quality of intact apple using near infrared spectroscopy. Journal of Food Science and Technology. 47(2):207-213.

Jordán MJ, Goodner KL and Shaw PE 2002. Characterization of the aromatic profile in aqueous essence and fruit juice of yellow passion fruit (*Passiflora edulis* Sims F. Flavicarpa degner) by GC−MS and GC/O.J. Agric. Food Chem. **6**: 1523-1528.

Krosnick SE, Yu XL and Deng YF 2013. The rediscovery of Passiflora kwangtungensis Merr. (subgenus *Decaloba supersection* Disemma): a critically endangered Chinese endemic. Phyto Keys**23**: 55-74.

Li Q, Zhang HB, Xie JL and Zhang HT 2011. High yield cultivation techniques of nuisance free passion fruit. Chinse. Horticulture Abstracts**8**: 154-155.

Silva CBMC, Jesus ON, Santos ESL, Corrêa RX and Souza AP 2014. Genetic breeding and diversity of the genus *Passiflora*: progress and perspectives in molecular and genetic studies.Int. J. Mol. Sci.**15**: 14122-14152.

Song Y, Wei XQ, Li MY, Duan XW, Sun YM, Yang RL, Su XD, Huang RM and Wang H 2018. Nutritional composition and antioxidant properties of the fruits of a Chinese wild *Passiflora foetida*. Molecules**2**: 459.

Souza MMD, Pereira TNS, Hoffmann M, Melo EJTD and Louro RP 2002. Embryo sac development in yellow passion fruit *Passiflora edulis* f. flavicarpa (Passifloraceae). Genet. Mol. Biol.**4**: 471-475.

Tian HQ, Ying YB, Lu HS, Fu XP and Yu HY 2007. Measurement of soluble solids content in watermelon by Vis/NIR diffuse transmittance technique.J. Zhejiang Univ-Sc. B.**2**: 105-110.

Zhang XJ, Xu L, Wei XQ and Xu JH 2017. Characters evaluation of five passion fruit germplasms. Southeast Horticulture**7**: 6-8.

(Manuscript received on 19 April, 2019; revised on 10 June, 2019)