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RESEARCH ARTICLE

EFFECTS OF DIFFERENT MATURITY STAGES ON THE QUALITY OF PURPLE PASSION FRUIT

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ABSTRACT

Fruit colour development and shrivelling are one of the major concerns of Vietnamese passion fruit industry as it reduces the appearance and downgrades fruit quality. The effects of colour stages were determined in purple passion grown in Gia Lai province, Vietnam. Immediately after harvesting, fruits were transported to the laboratory in Ho Chi Minh City and stored at 20 ºC. Data showed that different maturity stages, *viz.,* skin colour development stages of purple passion fruit significantly affected the quality including colour development and chemical properties.

KEYWORDS

passion fruit, colour, maturity, quality

1. INTRODUCTION

Passion fruit is native to South America (Brazil), belongs to the family *Passifloraceae* and is grown mainly in the tropics and subtropics. Passion fruit is a tropical vine with thin vines, tens of meters long, with delicious taste and high nutritional value. The seasons for high yield are March - May and August - December. Currently, passion fruit is grown in a number of countries such as Thailand, Australia, South Africa and Vietnam in which there are two popular varieties of passion fruit: purple passion fruit variety (*Passiflora edulis Sims*.) and yellow passion fruit variety (*Passiflora edulis f. Flavicarpa*) (Aguiar-Menezes et al., 2002). Passion fruit loses a significant amount of moisture if stored in low humidity conditions, leading to skin shrivelling and loss of aesthetics (Díaz et al., 2012). To avoid shrivelling and excessive weight loss, passion fruit should be stored at suitable humidity.

Storing passion fruit in perforated plastic bags or PVC packages will reduce moisture loss and shrivelling (Rinaldi et al., 2017). The peeling phenomenon does not adversely affect the quality of the pulp. In fact, passion fruit with shrivelled skin tends to taste sweeter (Joy, 2016). Due to the price fluctuation of passion fruit in the market, many farmers have not harvested the passion fruit at the right maturity when the market is at a high price, which has reduced the quality of passion fruit because of the problem of skin colour development. Therefore, the present research aimed to study the effects of different maturity stages, viz., colour development level on fruit quality thereby providing insights into additional measures and prevention methods to enhance overall passion fruit quality in commercial consignments

2. MATERIALS AND METHODS

2.1 Materials

Purple passion fruits were harvested from an orchard in Gia Lai province, Viet Nam. The fruits were collected at four different maturity stages, *viz.,* under 25% purple colour turning (stage 1), 25-50% purple colour turning (stage 2), 51-75% purple colour turning (stage 3), and over purple 75% colour turning (stage 4). The fruits were then transported to the post-harvest laboratory in Ho Chi Minh City. On arrival at the Postharvest laboratory, the fruits were stored in a ripening room at 20 ± 1°C. Twenty-four fruits per stage were used in this experiment. Physiological and fruit quality parameters were recorded every second day.

2.2 Quality assessments

2.2.1 Skin colour development

Skin colour was objectively measured using a CR 400 Chroma Meter (Konica Minolta, Japan). Colour was determined with two measurements per fruit (stem end and central region) and repeated every second day at the same position. Values were obtained for lightness (L) and chroma (C) and hue angle (h°) as calculated using 'a' and 'b' values by LabLchConversions (Semba et al., 2002). L value represents the lightness of the colour with 0 for black and 100 for white. C data represents colour saturation for h° representing colour space chroma position where red-purple is an angle of 0°, yellow is 90°, bluish-green is 180°, and blue is 270° (McGuire, 1992; Semba et al., 2002).

Skin colour was also subjectively rated using the following scale: 0 = 100% green, 1 = 90% green and 10% purple, 2 = 70-80 % green and 20-30% purple, 3 = 40 – 50% green and 50-60% purple, 4 = 5 – 15% green and 85 – 95% purple, 5 = 100% purple and 6 = 100% purple and very dark purple, no shining, sometimes wrinkled.

2.2.2 Overall fruit quality assessment

Overall fruit quality was assessed using a subjective four-point scoring system; 1 = high-quality fruit with glossy skin and no signs of dehydration, shrivelling, decay or bruises; 2 = acceptable fruit quality with dull skin and slight signs of shrivelling, bruises and softness; 3 = unacceptable fruit with dull skin and moderate signs of shrivelling, browning, dryness, bruises and softness; and 4 = poor quality fruit with evident signs of shrivelling, pitting,

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significant softness, decay.

2.2.3 Fruit shrivel

Fruit shrivel was scored using a five-point scoring system; 1 = no skin shrivels, full plump fruit; 2 = slight shrivel (<10% shrivel); 3 = light shrivel (<25% shrivel); 4 = moderate shrivel (50% shrivel); and 5 = severe deep shrivel (Golding et al., 2015).

2.2.4 TSS

Prior to instrumental analysis, the samples were thawed and squeezed through two layers of cheesecloth to extract the juice. The TSS (°Brix) of juice samples was determined at room temperature using a PAL-1 digital hand-held "Pocket" refractometer (Atago, Japan).

2.2.5 TA

Flesh samples were collected and stored as above. Prior to instrumental analysis, they were thawed and blended with a stick blender. TA of 10 g samples of the homogenised pulp in 100 ml distilled water and then determined with a titrator using 0.1 M NaOH as the titrant. TA was expressed as the citric acid equivalent (%) in each sample.

2.3 Data analysis

The data were subjected to analysis of variation (ANOVA) with Minitab software with maturity stages and storage time as the sources of variation. Differences between means were tested using least significant differences (Fisher's protected LSD) at $P \leq 0.05$.

3. Results and Discussion

3.1 Skin colour development

The passion fruit from all stages showed significant development of skin colour during storage. The fruit all stages turned to red and then dark purple and purple peels. The fruit from stage 4 turned to dark purple and appeared wrinkled at the end of storage (Table 1). Degradation of chlorophyll and the production and degradation of anthocyanins and carotenoids lead to colour changes in the fruit (Montero-Calderón and Cerdas-Araya, 2012).

Table 1: Skin colour rating scores of passion fruit from different maturity stages during storage

Maturity stage	Day 0	Day 3	Day 5	Day 7	Day 9	Day 11	Day 13
Stage 1	1.7l	3.5g	4.6e	5.4cd	5.7abc	5.8abc	5.8abc
Stage 2	2.4h	4.0f	5.4cd	5.8abc	5.8ab	5.4cd	5.7abc
Stage 3	3.3g	4.3ef	5.1d	5.5bcd	5.8abc	5.9ab	6.0a
Stage 4	4.2ef	5.2d	5.8abc	5.9ab	6.0a	6.0a	6.0a

Means that do not share a letter are significantly different (P≤0.05) as tested by Fisher's protected LSD.

The *L ** values gradually increased at the later storage time. The results regarding the *L ** value showed significant differences among skin colour stages ($P \leq 0.05$). In the last storage period, the *L ** value was not significantly different between stages. Decreasing *L ** value indicates an increase in dark purple colour and progression to browning of passion fruit peel after storage time when passion fruit turns from green to purple with passion fruit peel losing moisture after storage time. This comes from an increase in anthocyanin formation during the ripening process of passion fruits (Pongener et al., 2014).

Table 2: The L* values of passion fruit from different maturity stages thorough storage period

Maturity stage	Day 0	Day 3	Day 5	Day 7	Day 9	Day 11
Stage 1	77.1b	66.7jk	66.8jk	67.7ij	68.5gih	69.3efgh
Stage 2	80.4a	70.2e	69.6ef	67.7ij	68.6efgh	69.3c
Stage 3	74.7c	71.8d	68.9fgh	66.5k	68.6fghi	69.4efg
Stage 4	77.6b	68.3hi	67.6ijk	66.9jk	68.4ghi	68.5fghi

Means that do not share a letter are significantly different (P≤0.05) as tested by Fisher's protected LSD.

The statistical analysis of data regarding *a** values showed significant differences ($P \leq 0.05$) among skin colour stages during storage. Increased *a** value indicates that passion fruit tends to change from green to red to purple, indicating that the longer it is stored, the peel will turn red to purple. The *b** value indicated the value representing the passion fruit peel from green to yellow. After the storage period, the peel colour of passion fruit stages 1, 2 and 3 turned red and purple while the peel colour of passion fruit from stage 4 turned dark purple.

Table 3: The a* values of passion fruit from different stages thorough storage period

Maturity stage	Day 0	Day 3	Day 5	Day 7	Day 9	Day 11
Stage 1	-7.9k	-5.5ij	-4.9ij	-4.5ghi	-3.7efgh	-3.5defgh
Stage 2	-5.7ij	-2.7bcdef	-2.0bcdef	-3.8fgh	-3.2cdefg	-2.7bcdef
Stage 3	-6.6ik	-1.1a	-2.1a	-4.6hi	-2.8bcdef	-2.4abcde
Stage 4	-1.8abc	-1.5ab	-2.7ab	-3.2cdefg	-2.1abcd	-1.8abc

Means that do not share a letter are significantly different (P≤0.05) as tested by Fisher's protected LSD.

Table 4: The b* values of passion fruit from different stages thorough storage period

Maturity stage	Day 0	Day 3	Day 5	Day 7	Day 9	Day 11
Stage 1	17.1bc	14.0jkl	13.9kl	14.6hijkl	15.3defghi	16.0cdef
Stage 2	19.8a	16.3bcd	15.5defghi	14.7 hijkl	15.2 defghi	15.9defg
Stage 3	15.0efghijk	17.3b	15.7defgh	14.0kl	15.3defghi	16.1cde
Stage 4	16.2bcd	14.8ghijkl	14.5ijkl	13.9l	14.9 fghijkl	15.1efghijk

Means that do not share a letter are significantly different (P≤0.05) as tested by Fisher's protected LSD

Table 5: The h values of passion fruit from different stages thorough storage period						
Maturity stage	**Day 0**	**Day 3**	**Day 5**	**Day 7**	**Day 9**	**Day 11**
Stage 1	115.2a	112.1ab	111.2ab	107.2bcd	104.0cdefg	102.4defgh
Stage 2	106.1cde	100.4fghij	101.1 efghij	104.8cdef	102.2defghi	99.6ghij
Stage 3	114.2a	93.7k	94.2k	108.7bc	100.7fghij	98.6hij
Stage 4	96.5j	96.2j	96.2j	103.3defgh	98.4hij	97.11ij

Means that do not share a letter are significantly different (P≤0.05) as tested by Fisher's protected LSD.

The statistical analysis of data regarding h values showed significant differences (P ≤ 0.05) among maturity stages during storage. After the storage period, stage 1 had the highest h value as compared to other stages.

3.2 Overall fruit quality

After the period of storage, the overall fruit quality of all stages decreased gradually since day 5 as the slightly wrinkled skin were due to moisture loss resulting in fruit dehydration. Although there were no significant differences among stages ($P > 0.05$), the results regarding overall fruit quality showed significant differences among storage time ($P \leq 0.05$) (Table 6).

Table 6: Overall quality of passion fruits from different maturity stages during storage	
Storage time	**Overall fruit quality score**
Day 0	1.0e
Day 3	1.1e
Day 5	1.9d
Day 7	2.0cd
Day 9	2.3bc
Day 11	2.4b
Day 13	2.9a

Means that do not share a letter are significantly different (P≤0.05) as tested by Fisher's protected LSD.

3.3 Fruit shrivel

There was no significant difference in fruit shrivelling among stages ($P > 0.05$). The results regarding overall fruit quality showed significant differences in fruit shrivelling among storage time ($P \leq 0.05$). Fruit shrivel increased significantly during storage. Dehydration occurs due to the difference in relative humidity between the inner atmosphere of the fruit and the surrounding air. Those losses are partly limited by the peel, which functions as a barrier against water evaporation (Montero-Calderón and Cerdas-Araya, 2012).

Table 7: The shriveling scores of passion fruit from different maturity stages during storage	
Storage time	**Fruit shriveling**
Day 0	1.0d
Day 3	1.3d
day 5	2.0c
day 7	2.1bc
day 9	2.4bc
day 11	2.5b
day 13	3.2a

Means that do not share a letter are significantly different (P≤0.05) as tested by Fisher's protected LSD.

3.4 TSS and TA

The results regarding TSS and TA showed significant differences among stages ($P \leq 0.05$). The fruits at stage 4 showed the highest TSS as compared to other stages. The fruits at stage 1 showed the lowest TSS as compared to other stages.

Table 8: The TSS and TA values of passion fruit from different stages after storage		
Maturity stage	**TSS**	**TA**
Stage 1	14.12a	4.57ab
Stage 2	14.75ab	4.26a
Stage 3	14.83ab	4.83ab
Stage 4	15.15b	4.53ab

Means within parameter (column) with different small letters are significantly different (P≤0.05) as tested by Fisher's protected LSD.

4. Conclusion

In conclusion, the research showed that better harvesting management can be approached by using skin colour development as an indicator of passion fruit maturity. The right maturity harvest significantly stimulates the colour development as well as enhanced the organoleptic quality.

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