



# Analysis of the Physiological Characteristics of 4 Orange Varieties in Kontum (Quang Ngai) and Can Tho, Vietnam

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**Abstracts**— *Studies on the characteristics and evaluation of genetic resources regarding physicochemical and morphological properties are necessary for selecting good orange varieties for Kon Tum (Quang Ngai). A selection and evaluation study was conducted at the Orange Research Program in Kon Tum (Quang Ngai) and Can Tho (as a control). The evaluation of citrus species regarding various quantitative and qualitative characteristics related to leaf, fruit, and seed morphology at the phenotypic level, yield, and yield composition of four different orange varieties was performed growing at KonTum (Quang Ngai). Juice content showed a maximum positive correlation with flesh weight, followed by fruit weight. The CT 36 orange had a thin peel, high firmness, and juice content (67.17%) was determined in Mãng Đen; reducing sugar content (7.52%) and 7.35% at Đắk Pxi). The Sanh orange. thick peel, poor hardness, sugar content (2.16-2.44%) and sourness (1.75-2.3%) were reported in Kon Tum; while sugar content (6.55-7.35%) was recorded in Honey oranges. High sensory value was reported in site Đắk Mar, fruit with high flavor, sweetness and overall juice impression. The existence of wide variation in morphological characteristics with the highest yield prospects was confirmed in Sanh oranges (35.72) followed by Honey oranges (34.62). Therefore, morphology is an effective tool for successfully establishing different citrus varieties. This review will emphasize the evaluation of oranges gene resources through the analysis of growth and yield-related traits as well as various physicochemical properties at four different locations of the plants at KonTum (Quang Ngai) and CanTho.*



**Keywords**— *Morphological characteristics, Oranges, qualitative characteristics.*

## I. INTRODUCTION

Quang Ngai province (KonTum) is strategically located in the central part of Vietnam This area grows a lot of oranges for export. Morphological characteristics and morphological methods on various agronomic traits related to the leaves, flowers, and fruits of citrus trees. Standardized morphology provides a practical and reliable means of distinguishing closely related crop varieties, especially in diverse agricultural climates of highlands and lowlands. Morphological characteristics play an important role in assessing genetic diversity, crop variety identification and improvement programs. Important characteristics such as plant shape, leaf morphology, fruit shape, peel texture, flesh characteristics and seed

characteristics serve as reliable markers for distinguishing crop varieties (Jaskani et al., 2006; Khan et al., 2008). These morphological differences facilitate field-level identification and provide a valuable resource for germplasm conservation and breeding programmes aimed at citrus improvement under subtropical conditions (Shivali Chauhan et al. 2025). Furthermore, sex selection is not always feasible because some of the plant varieties used in hybrids are incompatible, sterile, or dabrionic (Talon and Gmitter, 2008). Orange Varieties in Vietnam. In Vietnam, many orange varieties are widely grown and developed, including:

- Mandarin oranges: grown in the mountainous regions of Northern Vietnam and the Mekong Delta. Mandarin oranges are a popular choice for refreshing juice.

- Citrus oranges: mainly grown in Central and Southern Vietnam. Citrus oranges have a characteristic sweet and sour flavor and are often used to make jam.

- Lemon oranges: grown in the mountainous regions of Central and Southern Vietnam. Lemon oranges have a slightly sour flavor and are often used to make refreshing drinks and juices.

- Xoan oranges: Xoan oranges have a sweet, fragrant taste.

- Sugar oranges: grown in the Western and Southern regions. Sugar oranges have a rich, sweet taste.

- Honey orange

- Canh orange: concentrated in the North

In addition, there are many other orange varieties grown in Vietnam such as Sanh orange.

Sanh orange is a fruit tree variety belonging to the Citrus genus (*Citrus reticulata* x *maxima*) with fruit almost like an orange, originating from Vietnam. Sanh oranges are easily recognizable by their thick, rough peel resembling the surface of pottery shards and are usually light green (turning orange when ripe), with orange flesh segments and rough skin. Subsequently, the development of yield and quality components of fruit grown at four different locations in Kontum was investigated. The aim is to produce high-quality citrus fruits (in terms of size, sugar and acidity balance, juice yield, and seedlessness), that are healthy and rich in antioxidant compounds, tolerant to or resistant to various abiotic and biotic threats, and with high yields. Conventional citrus breeding is a lengthy and expensive process; long periods and resources are required to obtain offspring and to evaluate their traits. This study allows us to clarify whether different fruit quality and environmental parameters at these four locations can lead to specific changes in seedless or seeded oranges, as well as their yields.

## II. MATERIALS AND METHODS

Four orange varieties were grown at three locations in Quang Ngai (1: *Đăk Mar*, 2: *Đăk Pxi*, 3: *Mãng Đen*) and one location in Can Tho (control group).

Morphological characteristics of leaves, flowers, pollen, and fruit.

Morphological characteristics of leaves (leaf blade size, leaf weight per unit, guard cell size, and stomatal density),

Flowers (size of flower buds, petals, pistils, and ovules, and number of petals, stamens, and ovules) and pollen grains.

Fully opened leaves and flowers just before blooming were collected in mid-July and mid-December of the following year, respectively.

Fruit height (mm): Measured from the bottom to the top of the fruit using calipers.

Fruit diameter (mm): Measured at the widest point of the fruit.

Peel thickness (mm): Averaged the peel thickness at 3 representative points.

Indentation diameter (mm): Measured the representative diameter of the indentation.

### Yield and yield components

Yield: Number of fruits/plant: Count all fruits on the plant at harvest.

Yield: Weigh all fruits at harvest.

### Yield Components

Section Weight: Separate the orange segments and weigh them using a TANITA technical balance manufactured in Japan.

Number of Segments: Count the total number of segments in the fruit.

### Fruit Quality Analysis

Fruit quality was assessed over two years (before and after the investigation). Twenty fruits were used for quality testing. Total Dissolved Solids (TSS) Content:

Extract the fruit juice and measure the Brix (%) of the juice using an ATAGO refractometer manufactured in Japan. The measurement range is 0-32%. The juice is dropped directly onto the prism of the refractometer and the results are recorded.

$$\text{TSS (\%)} = 0 \text{ Brix} * (1 + V/W)$$

Where:

V: Volume of dissolved water (ml)

W: Sample weight (g)

Titration Acidity (TA): Grind 2g of sample with distilled water to make 25ml. Take 2ml of the extract and add 2ml of 5% PEG (polyethylene glycol 5%). Centrifuge at 3000 rpm for 5 minutes. Then, take 0.5ml of the extract and add 9.5ml of distilled water for titration. Add 2-3 drops of phenolphthalein (1%), shake well, and titrate with 0.01 M NaOH until a stable pale pink color is obtained. Simultaneously, perform a blank test with the 5% PEG solution by taking 0.5ml of PEG, adding 0.5ml of distilled water, then taking 0.5ml of the mixture and adding 9.5ml of distilled water for titration, similar to the real sample.

The results are calculated as follows:

$$TA(\%) = ((V_f - V_0) \times 0.01 \times K \times 100) / ([W / (W + V_n)] \times V_m)$$

Where:

$V_f$ : Volume of actual titrating NaOH solution (ml)

$V_0$ : Volume of blank titrating NaOH solution (ml)

$V_n$ : Total volume of sample solution (ml)

$V_m$ : Volume of diluted solution used for titration (ml)

W: Mass of sample (g)

0.01: Concentration of NaOH used for titration

K: Characteristic coefficient for citric acid 0.064

The peel color is evaluated using a color chart (FUJIHIRA INDUSTRY Co. Ltd., Tokyo, Japan). The degree of peel swelling is assessed using a scale from 0 (no swelling) to 3 (severe swelling) upon touch.

Vitamin C analysis: Ascorbic acid was determined by titrimetric method as described by Ranganna (1995). Vitamin C (mg/100g): Quantitative determination of vitamin C by titration with 2,6-dichlorophenol indophenol (Murin, 1990). Weigh approximately 5g of sample into a porcelain mortar with 20ml of 1% HCl and crush the sample. Then, add 100ml to a volume of 1% oxalic acid, shake well, and let the solution stand for 10 minutes. Next, take a 10ml sample and titrate it with 0.001N 2,6-dichlorophenol indophenol solution until a persistent pink color appears after one minute, then stop the titration. Read the volume of 0.001N 2,6-dichlorophenol indophenol solution used. Repeat the analysis 3 times. The control sample was titrated with 2ml of 1% HCl and 8ml of 1% oxalic acid as described above.

The vitamin C content in 100g of fresh sample was calculated using the formula:

$$X = ((a-b) \times 0.088 \times V_1) / (V_2 \times m) \times 100$$

Where:

a: Average number of ml when titrating the sample.

b: Average number of ml when titrating the control sample.

$V_1$ : Initial volume of extraction solution (100ml).

$V_2$ : Volume of extraction solution for titration (10ml).

0.088: Number of mg of ascorbic acid equivalent to 1ml of 2,6-dichlorophenol indophenol titration solution.

m: Initial sample weight (g).

The sugar and organic acid content of the juice was determined according to the method of Mukai et al., (1996). Sugar content was calculated using sucrose, fructose, and glucose. For organic acid content, citric and malic acids were measured. Ten types of fruit were used for analysis. The determination and quantification of

carotenoids in fruit juices were carried out according to the methods (Kato et al., 2004).

### III. RESULTS AND DISCUSSION

#### 3.1 Analysis of Honey Oranges (Cam Mat)

In the third year, honey orange trees began to fruit, although the quantity was very small, 120.7 fruits per tree at *Dăk Mar* site.

The trees developed very well, and began to flower in July 2025. The number of flowers was very large. The level of male infertility (pollen) varied among orange varieties. Planting density often leads to seedless or few-seeded fruit when planted without cross-pollination (Yamamoto et al., 1995). This phenomenon has been observed in honey orange varieties. The number of flowers was very large, but the pollination rate was low.



Fig.1. Honey orange tree beginning to flower at *Dăk Mar* (Phuoc 2025)

Meanwhile, the orange fruit contains essential oils. The outer peel of the fruit turns orange or yellow when ripe, while the inner peel is odorless, spongy, and white. An orange usually consists of about 12 separate wedge-shaped compartments. Each compartment may contain at least 2 to 4 irregular white seeds. The flesh of a ripe fruit may be yellow.

This is a type with pale yellow flesh, low acidity ranging from 0.76 to 0.87%, not harsh or sour when eaten, only a refreshing sweetness. They have very few seeds and are difficult to peel. In addition, their flesh has a juicy flavor

ranging from 72.38 to 79.51%, averaging 76.93%, making them an excellent choice for fresh consumption. Vitamin C content varies from 64.7 to 73.38%.

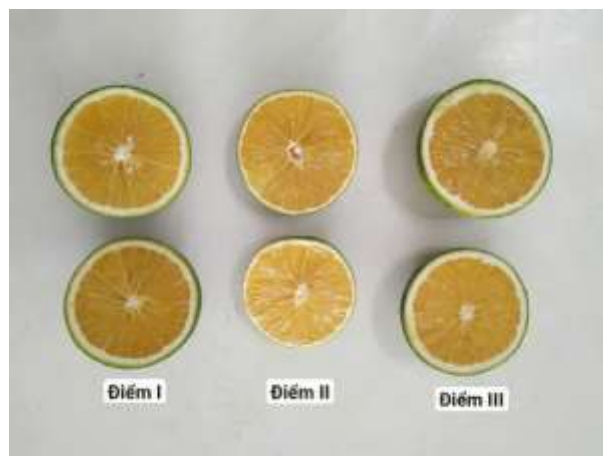
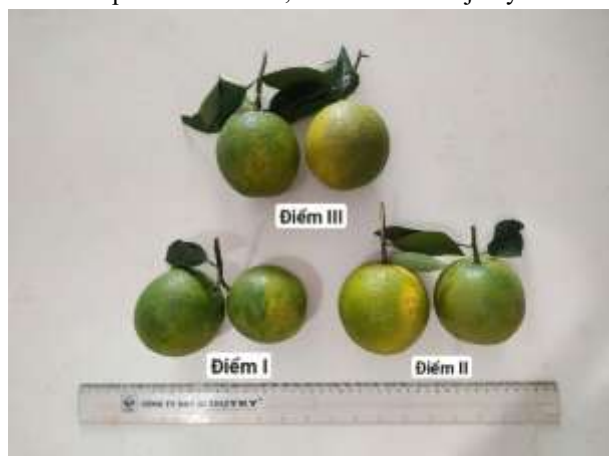


Fig.2. Honey oranges harvested at 3 experimental sites in the third year (Lang 2025)

Table 1. Analysis and evaluation of yield, yield components and quality of Honey oranges in the third year

| sites | Hight (m) | Number fruit/ tree | Weight of fruit (gram) | number of segments in an orange | Numbers seeds/ fruit | yield/ ha | sweet | juicy flesh (%) | Suger | Vitamin C (mg/g) | sour (%) |
|-------|-----------|--------------------|------------------------|---------------------------------|----------------------|-----------|-------|-----------------|-------|------------------|----------|
| 1     | 2.6c      | 120.7c             | 11.8b                  | 360b                            | 1.9b                 | 33.4b     | 2.2a  | 79.51a          | 6.67b | 73.38a           | 0.82a    |
| 2     | 2.53d     | 140.4a             | 12a                    | 342c                            | 3.2a                 | 32.2c     | 1.9b  | 72.38d          | 7.35a | 67.16b           | 0.87a    |
| 3     | 2.8a      | 130.5b             | 11.7b                  | 250d                            | 3.3a                 | 30.1d     | 2a    | 78.95b          | 6.55b | 64.7b            | 0.76b    |
| 4     | 2.7b      | 140a               | 12a                    | 420a                            | 3a                   | 42.8a     | 2.5a  | 75.6c           | 6.85b | 69.1b            | 0.7b     |
| mean  | 2.65      | 130.65             | 11.87                  | 343                             | 2.85                 | 34.62     | 2.15  | 76.61           | 6.85  | 68.68            | 0.78     |

Note : 1: Đắk Mar, 2: Đắk Pxi, 3: Măng Đen, 4: Can Tho

### 3.2. Analysis of Sanh Oranges

This analysis of Sanh oranges is characterized by the formation of a rough-skinned fruit – a berry with a tough, oily peel surrounding swollen, juicy sacs inside. Citrus trees are perennial evergreens, maintaining a complex tree structure with one to three distinct annual vegetative growth cycles. Sanh oranges flower and bear fruit annually in subtropical conditions, with flowering in spring, largely dependent on rainfall or adequate water supply. Fruit yield varies from 130.2 to 140.4 fruits per tree in the third year. Sanh oranges are easily recognizable by their thick, rough peel resembling the surface of pottery shards, usually light green (turning orange-yellow when ripe), with orange-yellow flesh and rough skin. A single orange typically contains about 12 distinct wedge-shaped compartments.

Each compartment may contain at least 3 to 4 irregular white seeds, with some fruits having 5 seeds. The flesh of ripe oranges can be yellow, easy to peel, and the juicy flavor varies from 85.79 to 88.49%, averaging 86.96%, making them excellent for refreshing juice. Vitamin C content is very high, varying by region from 74.26 to 77.57 mg/g, averaging 75.42 mg/g. Sweetness is low, acidity is high, varying from 1.75 to 2.3%. The aroma is easily recognizable thanks to the flavor of the peel, which contains many essential oils.

Analysis of seedless orange varieties on Sanh oranges. Seeds play an important role as a source of phytohormones necessary for fruit development, including regulating fruit size (Balaguera et al., 2020). In addition, fruit size significantly affects the marketability of oranges

(Bons et al., 2015). Generally, seedless fruits, due to mutations preventing seed formation, tend to be smaller than seeded fruits. Seedless Sanh oranges are smaller than seeded varieties (Figure 3.). Plant hormone status, including auxin and gibberellin concentrations, may influence early fruit development in seedless citrus fruits (Mesejo et al.,

2016). Hypothesized, hormonal changes and regulatory processes during the seedless fruiting (parthenocarpic) stage may have contributed to its increased fruit size. This unique characteristic, combined with the absence of seeds, further enhances the commercial value of the Sanh orange variety.



Fig.3. Harvested Sanh oranges at 3 experimental sites in the third year (Lang 2025)

Table 2. Analysis and evaluation of yield, yield composition, and quality of Sanh oranges in the third year

| sites | Hight (Cm) | Number fruit/ tree | Weight of fruit (gram) | number of segments in an orange | Numbers seeds (seed/ fruit) | yield/ ha | sweet | juicy flesh (%) | Suger | Vitamine C (mg/g) | sour (%) |
|-------|------------|--------------------|------------------------|---------------------------------|-----------------------------|-----------|-------|-----------------|-------|-------------------|----------|
| 1     | 3.01a      | 130.2c             | 12.1a                  | 3.7b                            | 350b                        | 33.5b     | 0.05  | 85.79c          | 2.16a | 77.57a            | 1.75b    |
| 2     | 2.94b      | 140.4b             | 12a                    | 3.2b                            | 320c                        | 32.4c     | 0     | 86.68b          | 2.44a | 74.44c            | 1.92b    |
| 3     | 3.04a      | 130.4c             | 12a                    | 3.9b                            | 300d                        | 31.5d     | 0.1   | 88.49a          | 2.18a | 74.26c            | 2.3a     |
| 4     | 3.25a      | 250a               | 12.0a                  | 4a                              | 410a                        | 45.5a     | 0.05  | 86.96b          | 2.26a | 76.2b             | 2a       |
| mean  | 3.06       | 160.5              | 12.03                  | 3.7                             | 345.0                       | 35.72     | 0.05  | 86.98           | 2.26a | 75.61             | 1.99     |

Note : 1: Đắk Mar, 2: Đắk Pxi, 3: Măng Đen, 4: Can Tho

### 3.3 Analysis of CT36 Oranges

CT36 oranges are high-yielding, sweet-tasting varieties with a slight hint of sourness (low acidity of 0.41-0.47%). They are easily recognizable by their deep orange color.

The flesh is very juicy, with a water content ranging from 69.26% to 71.42%. The vitamin C content is very high, varying by region from 57.62 to 65.4 mg/g. The sweetness level is high (grade 3). Harvesting takes place from December to February, with the peak season in January



Fig.4. A mature orange flower and its various parts connected to the bud via the flower stalk on Sanh orange variety at Đắk Mar (Phuoc 2025)



Fig.5. Harvested CT36 oranges at 3 experimental sites in the third year (Khoa.2025)

Table 3. Analysis and evaluation of yield, yield composition, and quality of CT36 oranges in the third year

| sites | Hight (Cm) | Number fruit/<br>tree | Weight of fruit<br>(gram) | number of<br>segments in an<br>orange | Numbers seeds<br>( seed/ fruit) | yield/ ha | sweet | juicy flesh (%) | Suger | Vitamin C<br>(mg/g) | sour (%) |
|-------|------------|-----------------------|---------------------------|---------------------------------------|---------------------------------|-----------|-------|-----------------|-------|---------------------|----------|
| 1     | 2.21b      | 50.6s                 | 11.5b                     | 220a                                  | 0.7b                            | 32.5b     | 2.0   | 69.26b          | 7.48a | 65.4a               | 0.47b    |
| 2     | 2.19c      | 70c                   | 11.3b                     | 200b                                  | 0.5c                            | 31.2c     | 2.0   | 71.42a          | 7.35a | 58.16c              | 0.41b    |
| 3     | 2.36a      | 80b                   | 11.3b                     | 195b                                  | 0.3d                            | 30.7d     | 2.0   | 67.17c          | 7.52a | 57.62d              | 0.43b    |
| 4     | 2.25b      | 100a                  | 12a                       | 150c                                  | 1a                              | 35.1a     | 1.5   | 65.2d           | 7.45a | 61.2b               | 0.5a     |
| mean  | 2.25       | 70.65                 | 11.52                     | 191.25                                | 0.62                            | 32.37     | 1.5   | 68.2            | 7.45  | 60.59               | 0.45     |

Note : 1: Đắk Mar, 2: Đắk Pxi, 3: Măng Đen, 4: Can Tho



Fig.6. The CT36 orange tree was planted at the experimental site Đắk Pxi (Phuoc 2025).

### 3.4. Analysis of V2 Oranges

Short-stemmed trees

This variety has a mildly sweet taste. They are easily

recognizable by their deep orange color and juicy flesh, varying from 70.3% to 74.31%. The vitamin C content is very high, varying by region from 59.02% to 62.65 mg/g. The sweetness level is high (1.5).

Table 4. Analysis and evaluation of yield, yield components, and quality of V2 oranges in the third year.

| sites | Hight (Cm) | Number fruit/ tree | Weight of fruit (gram) | number of segments in an orange | Numbers seeds ( seed/ fruit) | yield/ ha | sweet | juicy flesh (%) | Suger | Vitamin C (mg/g) |
|-------|------------|--------------------|------------------------|---------------------------------|------------------------------|-----------|-------|-----------------|-------|------------------|
| 1     | 1.43a      | 50.4c              | 210a                   | 10.3a                           | 1                            | 28.7a     | 1.5   | 73.45b          | 7.45b | 62.43            |
| 2     | 1.35b      | 120.5b             | 200b                   | 10a                             | 1                            | 25.2b     | 1.5   | 70.3c           | 7.83a | 59.02            |
| 3     | 1.31b      | 140.8a             | 200b                   | 10a                             | 2                            | 20.8c     | 1.5   | 74.31a          | 7.47b | 62.65            |
| mean  | 1.63       | 100.9              | 203 .3                 | 10.1                            | 1.5                          | 24.9      | 1.5   | 72.68           | 7.58  | 61.36            |

Note: 1: Đăk Mar, 2: Đăk Pxi, 3: Măng Đen, 4: Can Tho

#### IV. DISCUSSION

The high water content of Sanh oranges makes them suitable for juice processing. Oranges have been shown to contain high levels of minerals, low moisture, low ash content, and crude fiber (Wall et al., 2006), and are a source of sugar, vitamins A, C, and B, protein, and low lipids (Ogbonna et al., 2013). Juices are non-alcoholic liquid products with a certain clarity and viscosity obtained by pressing or crushing the fruit with or without added sugar or carbon dioxide (Costescu et al., 2006). Măt oranges are large, about 2-3 fruits/kg. Sanh oranges are of similar size, about 2 fruits/kg. CT36 oranges are medium-sized, about 3-4 fruits/kg. V2 oranges are small, about 4-5 fruits/kg. Oranges are a distinct fresh fruit, widely consumed and especially valued for their delicious flavor. Fruits and their juices constitute one of the most important foods for humans. Regular consumption maintains health and compensates for dietary deficiencies. The Sanh orange variety adapts well to the conditions at Đăk Mar and Măng Đen locations. The table shows that Sanh oranges have the highest juice content at 86.96%, while other orange varieties show 69.28% for CT 36 oranges, 72.68% for V2 oranges, and 76.94% for Mat oranges. Oranges are an excellent source of vitamin C. The different orange varieties in the experiment showed varying vitamin C content, with Sành oranges providing the highest levels (7.26–77.57 mg/g), followed by Mat oranges (64.7–73.38 mg/g). Oranges CT36 (57.62-65.4 mg/g) and V2 (59.02-62.43 mg/g) are rich in vitamin C. Besides vitamin C content, orange juice is also rich in folic acid, potassium, and is an excellent source of secondary compounds with high antioxidant activity, making them important commercial commodities in most countries (Vasavada et al., 2003).

The CT 36 orange has a thin peel, high firmness, and juice content (%) determined in Măng Đen; reducing sugar content (7.52%) and 7.35% at Đăk Pxi. The Sanh orange

has a thick peel, low firmness, sugar content (2.16-2.44%) and sourness (1.75-2.3%) reported in Kon Tum;

while the sugar content (6.55-7.35%) was recorded in the Mat orange. High sensory value was reported in the Đăk Mar fruit with high flavor, sweetness, and overall juice impression. The existence of wide variation in morphological characteristics confirms the highest yield potential in the Sanh orange variety (35.72), followed by the Mat orange (34.62). Seedlessness in oranges usually arises from a combination of factors rather than a single cause. The external environment, in addition to common infertile types, also has a significant impact on flower development and seed formation in the fruit. Seedlessness can be achieved by combining pollination without fertilization with factors that inhibit normal fertilization (Varoquaux et al., 2000). Several environmental factors, such as low or high temperatures, chromosomal abnormalities, and certain chemical treatments, can cause seedlessness (Ali et al., 2013). Irregular seed and fruit formation is particularly pronounced when plants are exposed to suboptimal or superoptimal temperatures during the flowering stage (Hedhly et al., 2011). Exposure to varying temperatures during bud development alters the expression of the autoincompatibility response (Distefano et al., 2018). This is consistent with the results in Kon Tum (Quang Ngai) where climate changes during the flowering stage.

#### V. CONCLUSION

In terms of fruit yield per hectare, the Sanh orange variety yielded the highest at 35.72, followed by the Mat orange variety (34.62%), and the V2 orange variety had the lowest yield (24.9). Regarding sweetness, the Mat orange was the sweetest, followed by the CT orange at 36. The Sanh orange variety showed the highest juice content. Juicy flesh of Sanh orange was 86.98%. Juice content showed a

maximum positive correlation with flesh weight, followed by fruit weight. The CT 36 orange had a thin peel, high firmness, and juice content (67.17%) was determined in Dak Ha; reducing sugar content (7.52%) and 7.35% at *Đăk Pxi*). The Sanh orange. thick peel, poor hardness, sugar content (2.16-2.44%) and sourness (1.75-2.3%) were reported in Kon Tum( Quang Ngai) ; while sugar content (6.55-7.35%) was recorded in Honey oranges.

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