Evaluation of the morphological and quality characteristics of new varieties of Papaya Agri Solinda

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Abstract. The availability of new varieties with high productivity, pest and disease resistance, environmental stress tolerance, and accordance with consumer needs are requirements for the papaya to be accepted in the market. This study was conducted to evaluate the new varieties of papaya Agri Solinda with superior characteristics such as a high number of fruits per plant, high productivity, medium fruit size, and a thick, sweet, slightly chewy texture, with a good fragrant fruit flesh. The plants were planted in a pairwise comparison design with three replications with 30 plants each at the Sumani Experimental Garden belongs to the Indonesian Tropical Fruit Research Institute on 2014-2015. The result showed that papaya Agri Solinda has better characteristics compared to the comparison such as medium fruit size, bright yellow color, chewy texture, and sweet taste of fruit flesh [TDS: 12-14o Brix] with productivity over 80 tons/ha on 7-8 months of the first harvest. The morphological characteristics, a unique or new, that Agri Solinda has a sweeter taste and higher of total dissolved solids [TDS] than the comparison varieties [Sari Gading].

1. Introduction

Papaya is a tropical fruit that originated in America. Papaya fruit has a high calcium content, protein, beta-carotene, iron, calcium, vitamins A and C [1][2][3]. Papaya also contains electrolytes with a fairly good amount, which is potassium and other important minerals such as calcium, iron, magnesium, phosphor, and zinc. The important phytonutrients that can be found in papaya are beta-carotene [276 µg], Beta Crypto-xanthin [761 µg] and Lutein-zeaxanthin [75 µg] [4]. The level of public consumption for papaya fruit increases if there is the availability of papaya with good quality according to consumer needs such as good shape, color, texture, taste and fragrant [5]. Its shown at Statistics Indonesia data, the papaya production in Indonesia was 675,801 tons in 2010 and increased by 955,078 tons in 2011 [6].

The availability of the good quality of papaya varieties with high productivity, pests and disease resistance, environmental stress tolerance, and following consumer needs are requirements that must be accomplished in the era of agricultural industrialization and free trade liberalization. Considering that fruit crops are expected to be new growth in the agricultural sector, efforts to produce high-quality superior fruit commodities with a high competitive advantage and high potential yield must be the main foundation of today's works.

Several types of papaya are favored by consumers because of their taste, texture, and shape. The preferred taste of papaya is sweet papaya with a texture that is not too soft. Also, consumers like various forms of papaya and can be adjusted to their needs. Papaya varieties that have a yellow flesh color have not developed much in Indonesia because it has a soft texture, does not smell fragrant and
is not sweet. Yellow fleshy papaya varieties commonly found in Indonesia include other local papayas with a soft texture and bad taste so consumers are not happy. Papaya Sari Gading has a yellow flesh color and a hard but not sweet texture so it is not suitable for fresh consumption.

Based on adaptation tests on some marginal land conditions, it can be seen that papaya Agri Solinda has a good adaptation to drought stress, hard soil texture and high rainfall [12]. This study was conducted to evaluate the new varieties of papaya Agri Solinda in 2015 with superior characteristics such as a high number of fruits per plant, high productivity, medium fruit size, and a thick, sweet, slightly chewy texture, with a good fragrant fruit flesh. Papaya Agri Solinda was a progeny from the crossing of Papaya M0-1 [female] and Mexican papaya [male]. M0-1 papaya and Mexican papaya comes from papaya exploration and selection activity in Indonesia. The parents have a similarity in the yellow color of the fruit flesh, but M0-1 papaya has a medium-sized while Mexican papaya has a small fruit size. The basic population of the S0 generation from the crossing result of these parents was distributed and selected until the S3 generation. The evaluation of S3 generation, based on superior characteristics of fruit yield and quality, it was determined that the accession of BT-4 is suitable as a candidate for a new superior variety because it has medium fruit size character, bright yellow flesh, sweet taste [TDS: 12-13o Brix], slightly chewy texture of fruit flesh and high productivity [> 80 tons/ha]. These characters are already uniform and established in some planted populations which then named Agri Solinda.

2. Material and Method
This research was carried out at the Sumani Experimental Garden belong to the Indonesian Tropical Fruit Research Institute, X Kota Singkarak district, Solok regency at an altitude of 350 m above sea level [asl], Red-Yellow Podzolic [andisol] soils with pH 4.5-5.0 and sandy clay characteristics.

Plant materials used in this study are Papaya Agri Solinda and Papaya Sari Gading as comparison varieties. Papaya Sari Gading variety is made as a comparison because it has the same fruit flesh color as the Agri Solinda variety. The plant was planted in a pairwise comparison design with three replications with 30 plants each so the total of plant population is 90 plants.

The morphological characters were observed including quantitative and qualitative characters. The morphological characters refer to Panduan Pengujian Individual [PPI] from Pusat Perlindungan Varietas Tanaman [8]. The plant's quantitative data include plant height, stem diameter, leaf length, leaf width, petiole length. The plant's qualitative data includes flower type, stem color, flower crown color, leaf, and petiole color. The pseudo-qualitative data of fruit quality includes fruit weight, fruit circumference, fruit length, flesh thickness, flesh color, fruit shape, flesh and skin hardness, and weight of 100 seeds. Chemical testing of the fruit flesh includes vitamin C, beta-carotene, water content, percentage of edible fruit and total dissolved solids [TDS] of fruit. A consumer preference test was conducted on 100 respondents by filling out a questionnaire.

3. Result and Discussion
Based on the observed papaya Agri Solinda has the advantage of the higher number of fruits per plant, fruit production per plant, and the highest total dissolved solids, and softer flesh and skin compared to papaya Sari Gading. Papaya Agri Solinda has the characteristic of bright yellow flesh, five-star shaped fruit cavity, bright green color on unripe fruit and dark green leaf color. The complete qualitative characteristics of papaya Agri Solinda shown in Table 1.

The qualitative character's observation of papaya Agri Solinda showed that the seed has a more round shape rather than the comparison. Papaya Agri Solinda has a weakness in the germination phase and low seed viability. It is likely due to the shelf life of seeds because papaya seeds have a relatively short shelf life[9]. Dies et al. [10] added that fresh papaya seeds undergo post-harvest dormancy that will break after six months of storage. The viability of papaya seeds is also influenced by the moisture content and nature of the seeds, papaya seeds at humidity and room temperature conditions can maintain seed viability for 12 months with 8% or 11% of moisture content. Wulandari [11] stated that papaya seeds are orthodox because they are resistant to storage at ± -20°C and intermediates because
they cannot withstand temperatures at ± -20ºC. If papaya has an orthodox type of seeds, then it is possible that the seeds can be stored for a long period, for more than 12 months. Figure 1 shows the shape of Sari Gading papaya as a local variety and Agri Solinda papaya crossing. Figure.1.a is the appearance of the Agri Solinda plant while Figure.1.c is the shape and flesh color of Agri Solinda.

**Table 1.** Morphological [qualitative] characteristics of papaya Agri Solinda and comparison varieties harvest season I [8 months after planting] and harvest season II [14 months after planting].

| Characteristics                      | Agri Solinda Harvest Season I | Agri Solinda Harvest Season II | Sari Gading |
|--------------------------------------|-------------------------------|-------------------------------|-------------|
| **STEM**                             |                               |                               |             |
| Stem cross-section shape             | Round                         | Round                         | Round       |
| Stem color                           | Greenish or Grey              | Greenish or Grey              | Beige       |
| **LEAF**                             |                               |                               |             |
| - Leaf shape                         | Palmately lobed               | Palmately lobed               | Palmately lobed |
| - Leaf color                         | Dark green                    | Dark green                    | Green-yellowish |
| - Petiole color                      | Dark green                    | Dark green                    | Beige-yellow |
| - Wax coating                        | Exist                         | Exist                         | Exist       |
| - Trichome                           | Not exist                     | Not exist                     | Not exist   |
| **FLOWER**                           |                               |                               |             |
| - Flower shape                       | Green                         | Green                         | Beige-yellow |
| - Sepal color                        | Green-whitish                 | Green-whitish                 | Beige       |
| - Petal color                        | Green-whitish                 | Green-whitish                 | Beige       |
| - Stigma color                       | Orange-yellow                 | Orange-yellow                 | Orange-yellow |
| - Stamen color                       | Green                         | Green                         | Beige-yellow |
| - Pedicel color                      | More male flower than         | More male flower than         | More male flower than |
| - Flowering type                     | hermaphrodite                 | hermaphrodite                 | hermaphrodite |
| **FRUIT**                            |                               |                               |             |
| - Fruit shape                        | Elongated                     | Elongated                     | Elongated to pear-shaped |
| - Unripe fruit skin color            | **Bright green**              | **Bright green**              | **Ivory**   |
| - Ripe fruit skin color              | Yellow-greenish               | Yellow-greenish               | Orange-yellow |
| - Fruit skin surface                 | Smooth                        | Smooth                        | Smooth      |
| - Fruit back                         | Flat                          | Flat                          | Flat        |
| - Fruit base shape                   | Sink down                     | Sink down                     | Sink down   |
| - Fruit tip shape                    | Blunt                         | Blunt                         | Blunt       |
| - Flesh color                        | **Bright yellow**             | **Bright yellow**             | **Ivory**   |
| - Fruit cavity shape                 | Five-star shaped              | Five-star shaped              | Five-star shaped |
| - Fruit taste                        | Sweet                         | Sweet                         | Sweetish    |
| - Flesh fragrance                    | **Fragrant**                  | **Fragrant**                  | **Strong**  |
| - Flesh texture                      | Slight chewy                  | Slightly chewy                | Chewy       |
| **SEED**                             |                               |                               |             |
| - Seed shape                         | Roundish                      | Roundish                      | Ovale       |
| - Seed color                         | Greyish                       | Greyish                       | Black       |
Figure 1. Papaya fruits of Agri Solinda [A, C] and Sari Gading [B, D].

3.1. The superiority of the papaya varieties

The comparison of some characteristics between Papaya Agri Solinda and Papaya Sari Gading has shown in Table 2.

| No | Characteristics                     | Agri Solinda          | Sari Gading           |
|----|--------------------------------------|-----------------------|-----------------------|
| 1  | Fruit weight [g]                     | 708.61 ± 250.53       | 723.75 ± 255.88       |
| 2  | Number of fruits per plant           | 51.96 ±18.37          | 45.00 ± 15.91         |
| 3  | Fruit production per plant [kg/plant]| 73.66 ± 26.04         | 33.15 ± 11.72         |
| 4  | Total dissolved solids [°brix]       | 13.11 ± 4.64          | 7.91 ± 2.80           |
| 5  | Fruit skin thickness [kg.cm⁻²]       | 0.67 ± 0.237          | 0.85 ± 0.30           |
| 6  | Flesh Thickness                      | 0.68 ± 0.24           | 0.81± 0.29            |
From the table above we know that the papaya Agri Solinda has a higher number of fruits per plant, fruit production per plant, and the highest total dissolved solids when compared to papaya Sari Gading. The number and weight of fruit are the main factors to determine crop production [12]. Papaya Agri Solinda has a softer flesh and fruit skin thickness [0.67 and 0.68 kg.cm-2] than papaya Sari Gading [0.85 and 0.81 kg.cm-2]. The large fruit papaya, however, tends to have undesirable characteristics as a lower fruit number per plant, lower percentage total soluble solid [sweetness] and lack firmness [7].

3.2. Consumer preferences
Organoleptic test results are shown in Table 3. that the panelists generally liked papaya Agri Solinda fruit due to a fragrant, very sweet, chewy texture of fruit flesh, and medium fruit size. The weakness of this variety is the yellow color of fruit flesh. Domestic consumers still think that yellow flesh is not sweet, but some foreign consumers like its characteristics. The character of sweetness in fruit can be known from the Total dissolved solids value of fruit flesh. The higher the value of Total dissolved solids, the taste of the flesh is sweeter and in general people like papaya with Total dissolved solids above 11oBrix [13].

| No | Parameter | Percentage [%] |
|----|-----------|----------------|
| 1. | Sweet Taste : | |
| | - Low | 0 |
| | - Fair | 1.44 |
| | - High | 98.56 |
| 2. | Chewy : | |
| | - Low | 0 |
| | - Fair | 9.44 |
| | - High | 98.56 |
| 3. | Acidity : | |
| | - Low | 100 |
| | - Fair | 0 |
| | - High | 0 |
| 4. | Fruit size : | |
| | - Big | 5 |
| | - Medium | 80 |
| | - Small | 15 |
| 5. | Fragrance : | |
| | - Low | 6 |
| | - Fair | 12 |
| | - High | 82 |
| 6. | The appearance of fruit flesh color : | |
| | Not attractive | 35.5 |
| | Quite attractive | 40.00 |
| | Very attractive | 25.5 |
| 7. | Likable: | |
| | Dislike | 0 |
| | Likable | 21.7 |
| | Very likable | 78.3 |

The organoleptic test resulted in Table 3. concluded that Papaya Agri Solinda is preferred by consumers even though the color of the fruit flesh is not very attractive. All panelists stated that the
fruit flesh did not have a sour taste and likable due to a fragrant, very sweet taste, and slightly chewy texture. Based on the color of the flesh, 35.5% of panelists stated the color is not attractive, while 40% stated it is quite attractive.

The consumers in the world like sweet papaya with bright colors like reddish Papaya was the favorite Australian papaya line. Consumers were surprised of its sweet taste given its blemished appearance and size, In Fiji, Fiji Red was the clear favorite papaya line amongst all participants. Consumers were most likely to buy due to its sweetness and color. According to Aisyah [14], the color of the fruit pulp choose by consumers is a reddish color, while the color of the fruit is yellow or pale not favored by consumers.

For fresh consumption, the properties of papaya fruit which is desirable include: small-medium [0.5 - 1.0 kg/fruit] or large [> 3 kg], flesh color orange to red, has a skin color green with red-orange [tinge] in she interrupted, cavity small fruit [edible portion height], rind smooth, the fruit comes from hermaphrodite flowers so that oval [oblong], a textured solid [firm], sweet taste without any bitterness or sense of sap, long shelf life and typical scented [15].

4. Conclusion
Papaya Agri Solinda is favorable by consumers because of the medium fruit size, a fragrant, sweet taste [TSS: 12-14° Brix], chewy texture of fruit flesh, and plant productivity above 80 tons/ha although it has a weakness, especially for the yellow color of flesh and low seed viability. As for the comparison, papaya Sari Gading papaya has a large fruit size, less sweet taste [TSS: 7-8° Brix] and slightly low productivity of 60 tons/ha. Further research needs to be done to improve the viability of papaya Agri Solinda which is still low.

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