

Study of the quality of fruits of the *Hylocereusundatus* (Haw) Britton & Rose and *Hylocereusmegalanthus*(K. Schum ex Vaupel) Ralf Baue (Red and Yellow Pitahaya) during the maturationperiod.

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Abstract— In this work, the organoleptic and sensorial characteristics were determined, as well as the maturation pattern of the yellow and red pitahaya fruits grown in Ecuador. Several fruit quality indexes were evaluated for 15 days from the moment of harvest, such as: weight loss, dry matter, total soluble solids, titratable acidity, exocarp coloration and maturity relationship and related damages by attack of biotic agents. The results indicated that in storage conditions with a temperature of 25 ± 1 ° C, the red pitahaya presents a gradual loss of fruit quality up to nine days; after this period serious fungal damage to the fruit that affects its commercial quality begins. The yellow pitahaya has a time of storage that can reach up to 15 days, although the fruit looks externally dehydrated and aged; however internally the fruit maintains its quality for consumption. It presents organosensitive standards of quality and resistance to microbiological agents superior to those of the red pitahaya.

Due to the behavior of the fruit in the various variables evaluated in this study, strong evidences are presented that suggest to consider it as a species of non-climacteric respiration.

Keywords— *Hylocereusmegalanthus*, *Hylocereusundatus*, quality parameter's, maturation period.

I. INTRODUCTION

The name pitahaya refers to the fruits of the species known as red pitahaya *Hylocereusundatus* (Haw) Britton & Rose and yellow pitahaya *Hylocereusmegalanthus* (K. Schum ex Vaupel) Ralf Baue (*Selenanthus* spp.), *Selenicereusmegalanthus* (K. Schumann ex Vaupel) Moran, belonging to the Cactaceae family (Rojas et al., 2008; Betancourt et al., 2010)

The cultivation of pitahaya for export is recent in Ecuador. *Hylocereusmegalanthus* (yellow pitahaya) and other native species have been cultivated for about 10 years in the Palora

canton of the province of Morona Santiago, with an area of more than 70 hectares (MAGAP, 2013).

Fruits are affected in postharvest by environment conditions and the handling that has been given of them. Due to ignorance of these aspects, these fruits are exposed to inappropriate temperature and humidity, to inadequate handling and to cuts and compression, which accelerate fruit respiration and perspiration processes, reducing their quality and shelf life (Bolaños, 2002).

The quality of the fruit depends on the physical characteristics such as integrity, shape, taste, color, aroma, freshness, texture and health; Besides being free of biological and chemical contaminants; Must be clean (free of spines), free of visible foreign matter (mainly in the apical foramen), and pesticides must not exceed the maximum limits established by the Codex Alimentarius (FAO, 2014).

Although this species is gaining importance as a crop in Ecuador, there are still not enough basic post-harvest management studies, which has motivated the present investigation.

II. MATERIALS AND METHODS

Geographic location: The work was carried out in a post-harvest fruit laboratory, located at km 26, east of Guayaquil, on the Durán - Tambo road, Virgen de Fátima parish, Yaguachi canton, Guayas province.

Characteristics of the mother plant: The plant where the fruits of the yellow pitahaya were extracted for the study was three years and eight months, an average height of 2.70 m, with an average yield of 94 fruits at its highest peak in the First crop of the year. The mother plant of the red pitahaya, was two years and six months, with a height of 2.70 m, with a yield of 61 fruits in production time.

Vegetable material: 100 fruits of each species were extracted from a commercial plantation located in Cerecita, province of Guayas, which were representative of the generality of fruits of the plantation in terms of size and external quality.

Groups of 10 fruits were randomly collected, and the physical-chemical characteristics were analyzed. The weight loss during the post-harvest was carried out at the time of harvest and at 4, 8, 12 and 16 days after harvest. In order to establish the ripening pattern and the fruit changes in the post-harvest, the fruits were weighed in grams and the percentage of dry matter was determined through the relation between wet samples and dry samples; the concentration of total soluble solids, through a graduated refractometer on a scale of 0-32 degrees Brix, titratable acidity, by titration technique with sodium hydroxide and malic acid was used as the reference. The methods used were those referenced by the AOAC (2012).

The color evaluation was carried out using a digital colorimeter with Stellar Net fiber optics. The readings were described based on the three values of the equipment that express changes of coloration by means of the index LAB: L (luminosity), A (changes of Green to red) and B (changes from blue to yellow). The methodology consisted in taking the color reading of the skin and pulp on both sides of the fruit, to detect the changes produced during the maturation process in postharvest. A circular mark of approximately 3 cm in diameter was made on the fruits on each of their side faces and the color was read at the indicated times. With the data obtained, chromaticity was established based on the definition of Chroma and angle Hue described by Morris and Townsend (Alvarado, 2011).

III. RESULTS

Figure 1. shows the results of weight loss of fruits of the two species under study, during the 15 days of post-harvest maturation.

The weight loss of the yellow pitahaya was 11.34%, whereas for the red pitahaya was 44.85%.

Table 1. shows the dry matter concentration data during fruit ripening days.

The values obtained for the yellow pitahaya did not present significant differences for $p \geq 0.05$, whereas the red pitahaya from the sixth day, presented significant differences with the initial value.

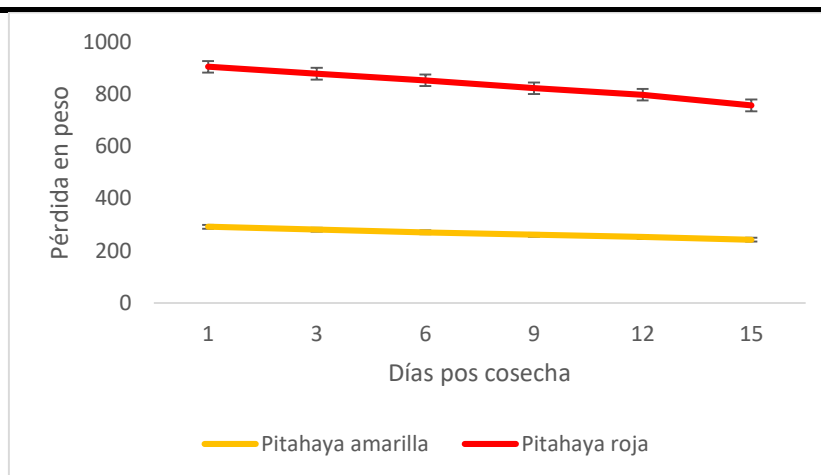


Fig.1: Weight loss of pitahaya fruits during 15 days of postharvest

Table.1: Changes in dry matter concentration of yellow and red pitahaya fruit during post-harvest maturation.

Treatment Days after harvest	Yellow Pitahaya %	Red pitahaya %
1	21,500a	27,200 b
3	21,500a	24,500 b
6	22,500a	23,060 bc
9	19,500a	22,000 bc
12	17,000a	19,500 bc
15	19,060a	15,000 c
CV	27,65	26,66

Legend: Different letters indicate significant differences for $p \geq 0.95\%$

Figure 2 shows the results obtained in the determination of total soluble solids (sugars), of the fruits under study (red and yellow pitahaya) throughout the post-harvest period. In the yellow pitahaya, the values of soluble solids were superior to the beginning of the experiment (day 1),

compared to the red pitahaya, and during the maturation period an increase in both fruits was observed, but superior in the yellow variety with significant differences ($p \geq 0.05$) between the days of the study.

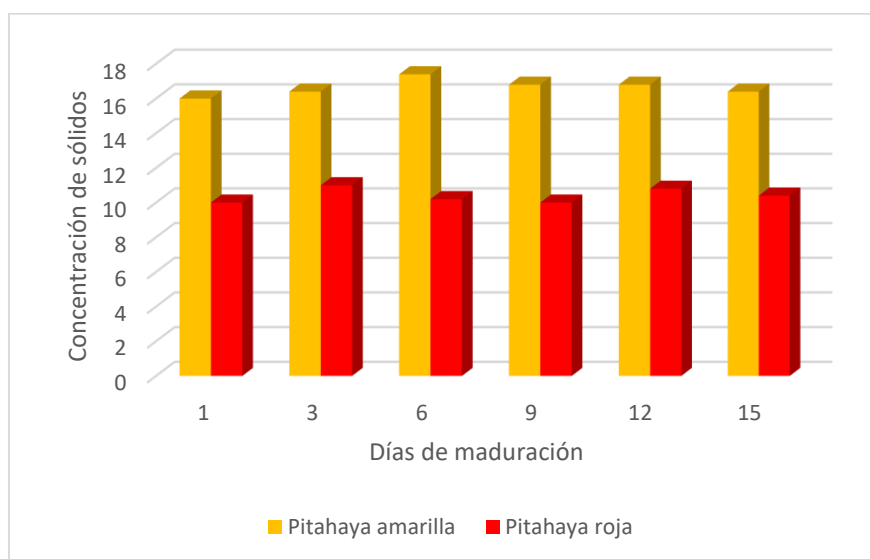


Fig.2: Changes in the concentration of soluble solids during maturation

The values of titratable acidity can be observed in Table 2, in which there is no trend of change for any of the fruits under study during the post-harvest period analyzed. The

acidity value of the fruits was similar in both cultivars and ranged from 1.20 to 1.28%.

Table.2: Percentage titratable acidity of yellow and red pitahaya fruits during post-harvest ripening.

Treatment Daysafterharvest	Yellow Pitahaya %	Red Pitahaya %
1	1,24	1,24
3	1,20	1,20
6	1,24	1,28
9	1,20	1,20
12	1,20	1,20
15	1,28	1,24
CV	11,90	11,90

The coloration of the epicarp calculated by the CROMA index is presented in figure 3, where it is observed that the fruits recently harvested from yellow pitahaya produce a slight increase in the color quality up to three days after the harvest (from 27.27 to 29.74); period after which the quality

of the color begins to degenerate, a situation that was observed until the end of the experiment (from 29.74 to 6.65). In contrast, red pitahaya undergoes a slight improvement in color expression from the time of harvest to 15 days after harvest (from 27.5 to 37.2).

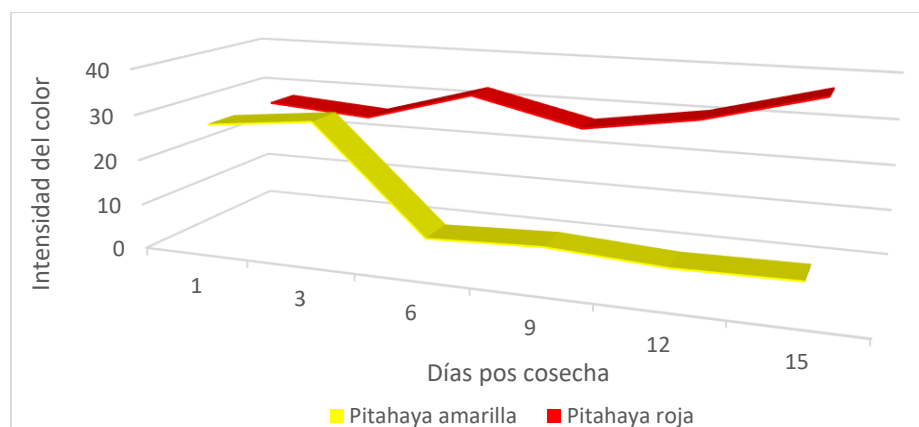


Fig.3: Changes in epicarp coloration of fruits during post harvest maturation

In the different periods of the evaluated post-harvest maturation, no statistical difference was observed between fruits in relation to maturity; however, the highest level of maturity ratio in yellow pitahaya was observed, where values between 13.04 and 14.69 were observed in comparison to red pitahaya, with values between 8.01 and 8.93.

During post-harvest maturation, the attack of cryptogamic agents was detected mainly in red pitahaya. On the sixth day of the experiment the presence of more or less regular spots of dark brown color was observed; these continued to grow until reaching a diameter of 5 cm and an extension of the spots as a whole that covered up to 90% of the fruit at the end of the experiment, which ended up completely

collapsing the fruit, which had exposed deterioration of its tissues. The growth of fungal structures corresponding to a mixture of white, green and black mycelia that after being analyzed under the microscope were identified as *Collectotrichum* sp, *Alternaria* sp, *Rizophus* sp and *Fusarium* sp (Fig 4) . The fungi were also found in yellow pitahaya, but these were not as aggressive and did not determine the collapse of the fruit. The main fungi found after the corresponding phytopathological analysis were: *Colletotrichum* sp, *Cladosporium* sp, *Verticillium* sp and *Penicillium* sp. (Fig 5)



Fig.4: Fungal damage on Red Pitahaya



Fig.5: Yellow Pitahaya fruit- 12 days post-harvest

IV. DISCUSSION.

The weight loss during the 15 days evaluation of the post-harvest maturation of the yellow and red pitahaya allowed to corroborate the universal pattern of weight loss that occurs in all the fruits during their maturation; which is basically due to the continuous removal of water and substrates in the form of CO₂, through transpiration.

Cano et al. (2000) pointed out that the greater the difference between the relative humidity of the surrounding air and that of the product, the greater the dehydration. It has been suggested that the process of transpiration brings intrinsic weight loss, wilting, softening of fruit and progressive loss of nutritive value.

Robayo, (2002), confirmed this statement showing that even using modified atmospheres in the conservation of pitahaya, the loss of weight of the fruit during post-harvest could not be avoided.

Magaña-Benítez et al., (2010), a study on cooling processes of pitahaya fruits in controlled atmospheres, pointed out the inevitable loss of weight of the fruit during post-harvest.

Arias and Toledo (2007) and Pauli and Duarte (2011) indicated that if the fruit lost 5% of its fresh weight, it was no longer suitable for commercialization.

In this study, it was observed that in the conditions under which the experiment was carried out, the yellow pitahaya after three days maintained its initial characteristics intact, but at 9 days it had already suffered a weight loss of 9.3% and at the end of the experiment the loss reached 11.34%. In the case of red pitahaya, losses were higher, presenting at 3 days a 9.9% loss in weight and at the end of the experiment a 44.85%.

Fruit respiration follows a pattern that divides them into climacteric and non-climacteric. The perishability of fruits is directly related to the rate of respiration, the higher the rate of respiration, the shorter the shelf life (Arias and Toledo, 2007).

In the case of the pitahaya there is conflicting criteria. For yellow pitahaya Díaz (2005), it was observed that it was a non-climacteric fruit with a respiration rate of 95-144 mg CO₂ / kgxh at 20 ° C, which contradicts Gallo's (1997) situation that placed it within the group of climacterics with a respiration rate of 20-80 mg CO₂ / kgxh at the same temperature.

In this study and based on the observed results, it can be suggested that both yellow and red pitahaya have a behavior that inclines towards a non-climacteric respiration, with short lifespan.

The concentration of dry matter in post-harvest fruits gives a logical pattern of concentration this being high values immediately after harvest, where the fruit is composed of still hardened tissues. Since the membranes and cell walls are still rigid, while as the fruit matures, they become hydrolyzed and the cell walls collapse, leading to an increase in the moisture content of the fruit. After harvesting the fruits, the content of water and dry matter decreases. Adams-Phillips, et al. (2003) also point out that the levels of hydrolytic enzymes that cause the metabolism of plant cell components and the ripening of fruits after harvest are increased, generating a decrease in the values of dry matter as measured as the fruit advances in its maturation.

Similar concentrations of sugars in the fruit of the red dragon fruit throughout the period postharvest study marks a typical behavior of the fruits are not climacteric, while the yellow there is a tendency to increase their Brix until the sixth day after harvesting and after this period no increase is

verified; In this variable the difference of degrees Brix present between the yellow and red pitahaya is remarkable, where the first of these it oscillates between 16 and 17,40 ° Brix and in the red pitahaya of 10 to 11 ° Brix. Studies carried out by Ramírez - Mora, et al. (2005), confirm that the lower soluble solids content was present in a fermented juice of red pitahaya, compared to the yellow one.

The concentration of organic acids of the fruit (titratable acidity) expressed in malic acid, showed an inalterability in terms of the concentrations during the whole maturation stage post-harvest of the fruit in the two cultivars studied. The values of titratable acidity of the fruit were similar in both and ranged from 1.20 to 1.28%, which is related to the study by Fernández et al. (2009), who stated that there was no variation of acidity Titrated in the pitahaya fruits of red, white and pink pulp.

Esquivel et al. (2007), indicated that in the pitahaya juice the main organic acid was malic acid, with concentrations of 8.20 and 6.08 g / l in the different genotypes of Costa Rica.

The titratable acidity values expressed by the fruits evaluated in this study are similar to the fruits studied by Camargo and Moya, (1995), harvested in state 5, those with titratable acidity percentages located in a range between 1.00 and 1 , 50%, at room temperature, similar to that applied in this investigation (25 ± 1 ° C).

V. CONCLUSIONS.

The results obtained allow us to arrive at the following conclusions:

In storage conditions with a temperature of 25 ± 1 ° C, the red pitahaya presents a gradual loss of fruit quality up to nine days. After this period, serious fungal damage to the fruit that affects its commercial quality begins.

The yellow pitahaya has a time of storage that can reach up to 15 days, although the fruit looks externally dehydrated and aged, internally the fruit maintains its quality of consumption.

The yellow pitahaya presents organ-sensorial standards of quality and of resistance to microbiological agents superior to those of red pitahaya.

Due to the behavior of the fruit in the various variables evaluated in this study and making a contribution to the lack of certainty about the type of respiration that this species possesses, strong evidences are presented that suggest to consider it as a species of non-climacteric respiration.

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