ISSN 0100-2945 DOI: http://dx.doi.org /10.1590/0100-29452018297
Revista Brasileira de Fruticultura

Post-harvest quality of 'Vitória' pineapple as a function of the types of shoots and age of the plant for floral induction

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Abstract- For the production and quality of pineapple fruits, the appropriate choice of the type of propagule to be used combined with the management of the ages for floral induction are important factors to reach the maximum of desirable characteristics that will define the success in the production of the pineapple and its good acceptance in the market. The objective of this research was to evaluate the post-harvest quality of fruits developed from different types of shoots and ages of floral induction of 'Vitória' pineapple. The experiment was carried out in a complete randomized block design with four replications. The plots were made up of the shoots (slip and sucker) and the subplots were composed of the different ages of floral induction (8, 10 and 12 months after planting and natural flowering). Evaluations of biomass characteristics of fruits with and without crown, circumference, length, diameter, firmness, translucency, pulp color and physicochemical quality were performed. No significant interaction was observed for the biometric and biomass variables, and the type of shoots influenced only the crown biomass and the central cylinder diameter, which were higher in the slips. In addition, for the attributes color, translucent area and firmness, no interaction was found, and they were influenced only by the induction times, except for the variable color referring to the intensity of green and red colors. Regardless of the types of the shootss evaluated in the environmental conditions of planting carried out in April 2015, the fruits originated from natural inductions and inductions at 12 months presented greater firmness, a desirable characteristic for export and industrialization, mainly for the processing of slices of pineapple, pieces in syrup and crystallized. The slips natural induced and induced at 12 months provided fruits with a greater ratio between soluble solids and acidity.
Index terms: *Ananas comosus* (L.) Merrill, flowering, physical-chemical characteristics, propagation.

Qualidade pós-colheita do abacaxi 'Vitória' em função de tipos de mudas e idade da planta para indução floral

Resumo – Na produção e na qualidade dos frutos do abacaxizeiro, a escolha adequada do tipo de propágulo a ser utilizado, em conjunto com o manejo das idades para a indução floral, são fatores importantes para que seja alcançado o máximo de características desejáveis que definirão o sucesso na produção da fruteira e sua boa aceitação no mercado. Objetivou-se, com este trabalho, avaliar a qualidade pós-colheita de frutos desenvolvidos de diferentes tipos de mudas e idades de indução floral do abacaxizeiro 'Vitória'. O experimento foi conduzido em delineamento de blocos ao acaso, em parcelas subdivididas, com quatro repetições, sendo as parcelas formadas pelos tipos de mudas (filhote e rebentão), e as subparcelas, compostas pelas diferentes idades da planta para indução floral (8, 10 e 12 meses após o plantio, e o florescimento natural). Foram realizadas avaliações das características de biomassa dos frutos com e sem coroa, circunferência, comprimento, diâmetro, firmeza, translucidez, coloração da polpa e qualidade físico-química. Não foi observada interação significativa para as variáveis biométricas e de biomassa, sendo que o tipo de muda influenciou apenas na biomassa da coroa e no diâmetro do cilindro central, que foram superiores nas mudas-filhote. Para os atributos cor, área translúcida e firmeza, também não houve interação e foram influenciados apenas pelas idades de indução, exceto para a variável de cor referente à intensidade das cores verde e vermelha. Independentemente dos tipos de mudas estudados, nas condições ambientais de plantio realizado em abril de 2015, os frutos originados de induções aos 12 meses e natural apresentaram maior firmeza, característica desejável na exportação e na industrialização, principalmente na fabricação de fatias de abacaxi, pedaços em calda e cristalizados. Mudas do tipo filhote, induzidas aos 12 meses e naturalmente, proporcionaram frutos com relação superior entre sólidos solúveis e acidez.
Termos para indexação: *Ananas comosus* (L.) Merrill, propagação, florescimento, características físico-químicas.

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Received: August 02, 2017.
Accepted: February 28, 2018.

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Introduction

Brazil is the second largest producer of pineapples in the world, producing over 2.6 million tons in 2014 (FAO, 2017). According to the Brazilian Institute of Geography and Statistics (IBGE), in 2016, the harvested area was approximately 68618 ha and the production was of 1756359 t, being a crop present in most Brazilian states (IBGE, 2017).

Most of the pineapple produced in Brazil is for domestic consumption, with only a small portion exported. The highest volume exported in the form of fresh fruit occurred in 2007, corresponding to 36764 t; however, since this year, exports have been reduced, and in 2016, a volume of 3014 t was recorded, representing a reduction of 91.8% (ALICE WEB, 2017).

The quality of the pineapple is one of the main obstacles for Brazilian exports, being fundamental for its effective participation in international trade (ABREU; CARVALHO, 2000; BENGOZI et al., 2007). Although the domestic market is still poorly demanding in quality, consumers who prefer fresh fruits are more and more demanding for differentiated products. Therefore, producers should seek to raise the quality standard for being competitive.

Included in the factors that contribute to the reduction of quality, the post-harvest is particularly noteworthy. Fruit quality is defined by the sensorial, nutritional and food safety attributes (Andrade et al., 2015); however, the required standard varies according to the market. For consumption of fresh fruits in the domestic market, they must present at least 900 to 1200 g, while for export, it varies from 700 to 2300 g (CEAGESP, 2003). Regarding the soluble solids content, the minimum acceptable value for commercialization is 12ºBrix (CBI, 2016; MAPA, 2017). Fruits that do fulfill those standards have low commercial value for fresh fruit consumption, nevertheless, they may be processed in the juice or sweet industry (VILELA et al., 2015). According to Manica (1999), for industrial processing, it is recommended a soluble solid content higher than 10.5°Brix and a titratable acidity of less than 1.35.

Several factors influence the quality of the pineapple fruit, mainly related to the cultivar and the agronomic management. Among the management strategies used, artificial induction of flowering stands out because the age when floral induction is performed in relation to the stage of vegetative development of the crop is extremely relevant since plants with higher reserves tend to produce fruits with larger biomasses (FASSINOU HOTEGNI et al., 2015).

The size and type of shoots directly influence the vegetative development of the plant (MARCOLAN et al., 2007) as shoots of different sizes may accumulate sufficient reserves in distinct periods of time (BARBOZA; CAMPOS, 1992). Thus, an important factor in the production and quality of the pineapple fruits is the appropriate choice of the type of propagule to be used, combined with the floral induction management since they will determine the desired quality standard according to the market requirements.

Therefore, the objective of this work was to evaluate the quality of post-harvest fruits in response to the use of different types of shoots and ages of floral induction of “Vitória” pineapple.

Material and Methods

Experimental area, planting material, experimental design and fruit harvest - The experiment was set in April 2015 and conducted at the Sooretama Experimental Farm owned by Instituto Capixaba de Pesquisa, Assistência Técnica e Extensão Rural (INCAPER) in the municipality of Sooretama, Espírito Santo, at 19º11’30’’ S latitude and 40º05’46’’ W longitude. According to the classification of Köppen (ALVARES et al., 2013), the climate of the municipality is classified as Aw - tropical humid, with dry winter and warm and humid summer, and the predominant relief is flat.

The pineapple (*Ananas comosus* L. Merrill,) cv. Vitória, was planted in the double row spacing of 0.90 x 0.40 x 0.30 m, at a plant density corresponding to 51,282 plants ha^{-1}. A sprayed irrigation system was used, and fertilization was carried out according to the results of the soil analysis and to the recommendation of the manual of liming and fertilization for the State of Espírito Santo (PREZOTTI et al., 2007).

The experimental design was a randomized block design with four replications, in a split-plot scheme. The main plot was composed by the types of shoots: slips ranging from 100 to 200 g and suckers ranging from 201 to 300 g. The split-plot corresponded to the periods of floral induction according to plant ages at 8 (December 2015), 10 (February 2016) and 12 months (April 2016) and the natural flowering as a control, according to the methodology of Kist et al. (2011). Each subplot was made up by 72 plants, and the fruits from the 20 central plants were used for the evaluation.

The data on the weather, temperature (minimum, maximum and average) in °C and rainfall (mm), for the experimental period were obtained by the automatic meteorological station of Linhares/ES (INCAPER, 2017) and can be seen in Figure 1.

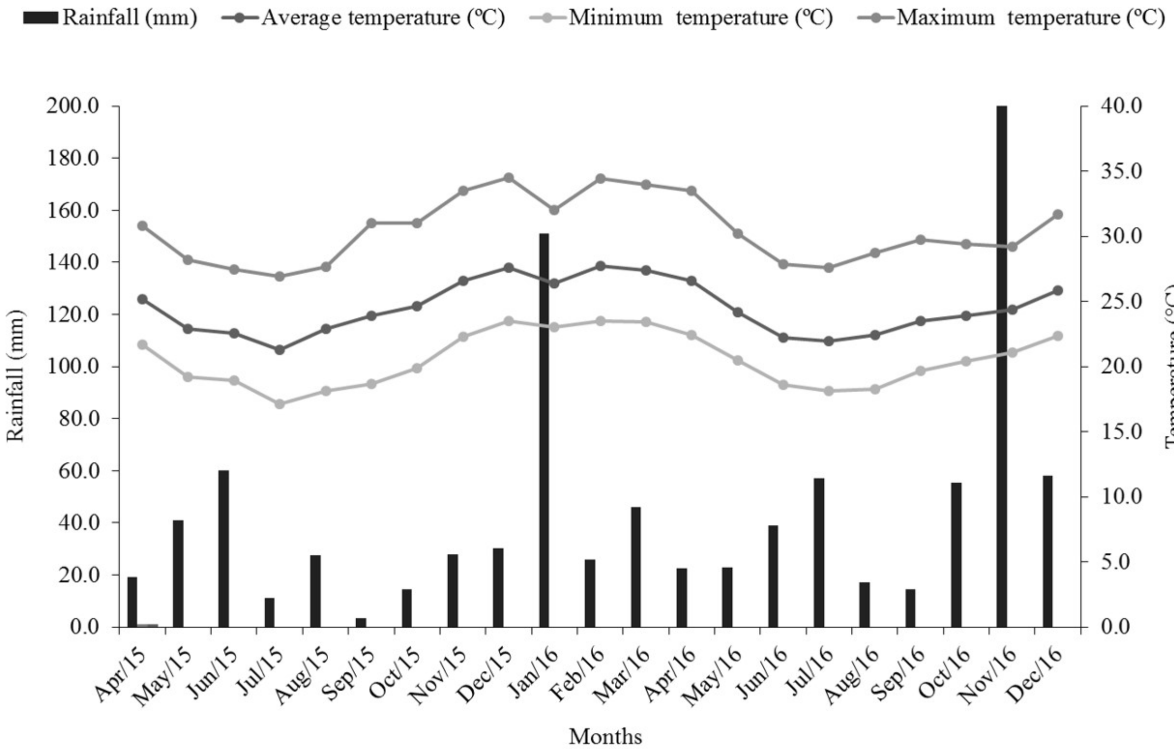

Figure 1. Data on total rainfall, maximum, minimum and average temperature of the air recorded at the weather station in Linhares-ES, from April 2015 to December 2016. Source: INCAPER, 2017.

Artificial floral induction was always carried out at early morning by applying ethephon (2-chloroethyl-phosphonic acid) based product at 100 mg L^{-1} on the leaf rosette at a dose of 30 mL per plant (KIST et al., 2011).

Fruit harvesting started in May 2016 and finished in December in the same year, being harvested at the maturation stage corresponding to the painted (up to 25% of orange-yellow peel), according to Normative Instruction/SARC no. 1 for white pineapple (MAPA, 2017). Immediately after the harvest, the fruits were sent to the Laboratory of Plant Physiology and Post-Harvest of the Regional Center for Rural Development Centro Norte, INCAPER, in the municipality of Linhares for evaluation of the post-harvest quality characteristics.

Biomass and Biometric characteristics - The fresh biomass of the fruit with crown (g), of the fruit without crown (g) and of the crown (g) were obtained by individual weighing of each fruit and the crown in a Shimadzu BL3200H semi- analytical scale. The biomass of the fruit without crown was obtained by the difference between the biomass of the fruit with crown and the biomass of the crown. The circumference (cm) and the length of the fruit without crown (cm) were determined through direct measurements with a tape measure and with the aid of a ruler graduated in centimeters, respectively. The fruits were sectioned in the transverse median region and evaluated for fruit diameter, pulp thickness (measured in cm between the bark and the central cylinder) and diameter of the central cylinder with a ruler graduated in centimeters.

Translucency characterization and pulp color – According to the percentage of the translucent area, the pulp was classified following Martins et al. (2012), using a visual scale where: 1 = completely opaque pulp; 2 = pulp with up to 10% of translucent area; 3 = pulp with 11% to 25% of translucent area; 4 = 26% to 50% of translucent area; 5 = pulp with 51% to 75% of translucent area, and 6 = more than 75% of translucent area. Pulp color was determined by direct reading at four points in the transversal median area of the fruit using Minolta Chroma meter CR-400, based on the CIELAB system, which was expressed in L*, a* and b*, evaluating through the color parameters: L* = brightness (0 = black and 100 = white); a* (-80 to zero = green; from zero to +100 = red) and b* (-100 to zero = blue, from zero to +70 = yellow), according to Carvalho et al. (2016). Darkening index of the pulp was calculated from the color parameters L*, a* and b*, using the following equation: $IE = (100*(X-0.31))/0.172$, according to Palou et al. (1999), where $X = (a^* + 1.75L^*) /5.645L^*+a^*-3.02b^*)$.

Physical-chemical quality - Fruit firmness was determined by the resistance to penetration, using the digital force gauge dynamometer Impac® model IP-90DI with an 8-mm cylindrical tip. Measurements were made at four sites in the middle region of the fruit with bark, in the middle portion of the fruitlet and the data were obtained in Newtons and converted to kilogram-force (kgf).

Afterwards, the fruits were peeled and crushed in a Philips Walita BR 700W Juicer centrifuge to obtain the homogenous juice for analyzes of yield and quality of the pulp. Pulp yield (%) was obtained through the volume/weight ratio and the values were converted into percentage. In the measurement of the volume of juice extracted in the individual fruit, reading was carried out in graduated cylinder (mL), then aliquots of the juice were removed to determine the chemical characteristics.

Juice quality was evaluated by analyzing the soluble solids (SS) (° Brix), titratable acidity (TA) (% citric acid), SS/TA ratio and pH, determined according to the Adolfo Lutz Institute (IAL, 2008). The soluble solids content was determined by reading in a Schmidt Haensch ATR-BR® digital refractometer with automatic temperature compensation within the range from 5 to 50ºC and a scale ranging from 0 to 100ºBrix using an automatic pipette for 1 mL of juice. The results are expressed in degrees Brix (ºBrix). The titratable acidity was determined by the titration method with 0.1 N NaOH, using the Titrino Plus Metrohm/848 automatic titrator previously calibrated by INMETRO, and the data are expressed as a percentage of citric acid in the juice. The SS/TA ratio (Ratio) was determined by the ratio between the two variables (SS/TA). For evaluation of pH, the digital bench potentiometer, pH lab Metrohm/827 model, with automatic temperature compensation, calibrated with buffer solution of pH 7.00, 4.00 and 9.00 was used.

The experimental data were submitted to analysis of variance and the means were compared by the test of Tukey at 5% of probability, using the statistical program Genes (CRUZ, 2013).

Results and discussion

Biomass, biometric and firmness variables

According to the analysis of variance, for biomass, biometric and firmness data, no significance ($p < 0.05$) was found for ages of floral induction applied in most of the evaluated characteristics, except for the crown biomass variable, which presented an overall mean of 119.16 g (Table 1). However, no significant interaction was found between shoots and floral induction ages for the evaluated variables.

The biomass of fruits with crown, regardless of the type of shoots, was higher in natural flowering, with approximately 58% of biomass gain compared to induction at eight months, significantly differing from the other induction ages. Close values were verified by Silva et al. (2012), when studying doses of N in 'Vitória' pineapple with flowering induction at 420 days after planting (14 months), when they found maximum biomass of the 1000 g fruit by applying 409 kg ha^{-1} of N.

According to the standards for pineapple classification of the Horticulture Quality Center (CQH)/ Companhia de Entrepostos e Armazéns Gerais de São Paulo (CEAGESP, 2003), for their fresh consumption, the fruits must present at least 900 to 1200 g for being marketed. The fruits that belong to the natural flowering in the present work are perfectly fit within this classification. For the international market, biomass of pineapple must be between 700 and 2300 g because very large fruits or with biomass less than 700 g have low commercial value for fresh consumption, however, they can be processed in juice or sweet industries (VILELA et al., 2015).

In addition, for the biomass of the fruits without crown, the behavior of the different evaluated vegetative structures was similar. The types of the evaluated shoots did not influence both characteristics in spite of the initial different weights of the two types of shootss - 100 g more for suckers. In contrast, Fassinou Hotegni et al. (2015), when studying the influence of shoots types on 'Sugar Loaf' pineapples, found a significant difference between the different shoots, that is, they observed greater weights of the fruits originated from the development of larger shoots.

Cardoso et al. (2013) working with irrigated 'Vitória' pineapple submitted to increased population density, and N doses in the northern region of Minas Gerais, observed that the plants induced at 18 months after planting produced biomass of the fruits with and without crown of 842.54 g and 713.69 g, respectively, which are values lower than those found in natural flowering fruits of the present study. However, Caetano et al. (2013) cultivar of 'Vitória' pineapple induced at 11 months after planting, observed values of 1247 g and 1138 g in fruit biomass with and without crown, respectively.

Only for the biomass of the crowns in slips, the average was superior to the one of the sucker type, whereas for the floral inductions no differences between them were observed. Due to the result, it is worth mentioning that in 'Vitória' pineapple, the weight of the fruit in the market will not be influenced by the weight of the crown, regardless of the age of floral induction performed in the field, noting that the weight of the crown is smaller in fruits from larger shoots. Similarly, Fassinou Hotegni et al. (2015), found an effect of the weight of planting material on fruits of smaller shoots which had heavier crowns than fruits of larger shoots. Silva et al. (2012), obtained values close to the present study, with a mean of 136.31 g crown biomass of 'Vitória' pineapple grown in the coast region in the state of Paraíba.

In relation to fruit firmness, a mean of 7.61 kgf (Table 1) was observed in the induction performed at eight months, which resulted in a lower firmness of the tropical fruit in the study. Close results were verified by Martins et al. (2012), when they observed firmness of 7.99 kgf in 'Pérola' pineapple grown in a conventional production system. However, Ramos et al. (2010), achieved a mean of 6.06 kgf in 'Imperial' pineapple, induced at eight months of age. In 'Vitória' pineapple, the value found for firmness was 8,195 kgf in fruits harvested under commercial plantation in the municipality of Itapororoca, Paraíba state (ANDRADE et al., 2015), close to that observed for the later and natural inductions.

The fruits of floral induction at 12 months after planting and natural flowering presented the highest mean values and did not differ significantly from each other, that is, in the later inductions, the fruits were physically firmer. These results corroborate with those found by Oliveira et al. (2015), when evaluating the influence of N and K doses on the physical-chemical quality characteristics of ‘BRS Imperial’ pineapple fruits with induction at 13 months after planting, verified an average of 10.7 kgf of fruit firmness. It is likely that the achieved result is due to the better formation of the fruits in relation to the consistency of their fibers, thus, being firmer and providing better resistance in the evaluation of the fruits belonging to the late induced plants, considering that they were harvested at the same maturation stage.

The evaluation of the firmness is important, especially the handling, storage and transportation of post-harvest fruits, since it has a considerable influence on the resistance of the fruits against mechanical shocks, assuring their longevity in shelves (VIANA et al., 2015), thus, the variable can be considered as a relevant indicator of the physical quality of ‘Vitória’ pineapple fruits. Therefore, later induction fruits presented adequate firmness, being able these to be destined to the industries and/or export according to their inferred resistance.

The biometric characteristics were higher for fruits resulting from natural flowering, with no statistical difference between the types of shoots, except for the central cylinder diameter (Table 2). The fruit circumference and diameter, as well as the pulp thickness, behaved similarly in their responses regarding the evaluated treatments, presenting the highest values in the fruits from the naturally induced plants (36.26 cm, 10.52 cm and 4.96 cm, respectively). The artificial induction in ‘Vitória’ pineapple plants resulted in fruits of lower circumference, diameter and pulp thickness, in the present work.

The shortest fruit length was observed in early induction plants at eight months after planting, not differing from those induced at 10 months. Comparatively, there was a difference of approximately 5.5 cm more in the length of the fruits obtained from the natural flowering. Ecologically, these results are consistent and demonstrate the need for the plant to reach a vegetative development so that it is mature enough to be able to receive photoperiodic stimuli and the apical meristem is the most sensitive to vernalization (CUNHA, 2009), promoting the induction of flowering and subsequent formation of the fruit. As a result, plants will perform better to produce larger, better-quality fruits. According to Carvalho et al. (2005), the induction of flowering, may still be related to fruit quality, confirming that the later induction allows the production of fruits more favorable to the market.

When working with infructescence of ‘Pérola’ and ‘Vitória’ pineapples grown under conventional nutritional management, Andrade et al. (2015) obtained fruit length of 14.13 cm and 12.21 cm for fruit diameter, both for cv. Vitória. In studies on fruit quality of pineapple cultivars from naturally induced slips for fresh fruit consumption, they found fruit length and fruit dimeter for cv. Vitória of 13.6 cm and 10.8 cm, respectively (BERILLI et al., 2014). Caetano et al. (2015), when cultivating genotypes resistant to Fusarium planted on May 2006 and induced at 11 months after planting, observed fruit length and fruit diameter of 14.7 cm and 10.9 cm in ‘Vitória’ pineapple, respectively. The values reported by the authors are close to those found in the present study.

The best result of the diameter of the central cylinder for the different types of shootss was observed in fruits originated from sucker type (0.91 cm), corresponding to the lowest value in comparison to slips (0.99 cm). Caetano et al. (2015), evaluating pineapple genotypes resistant to Fusarium in comparison to susceptible commercial cultivars, found in cv. Vitória, the lowest diameter of the central cylinder, 1.0 cm, a value close to those of the present study. The largest mean found at different ages of induction was at eight months after planting, with central cylinder of 1.24 cm of diameter. Although the variable is considered of lower value in comparison to the cultivars Pérola, Smooth Cayenne, among others (VENTURA et al., 2006; CAETANO et al., 2015), it is necessary to study the characteristics of the different management within the same cultivar, due to its importance, since fruits with smaller diameter of the central cylinder tend to show greater gains in pulp, attributing the best results to them.

Thereby, according to the results obtained in this work, it is verified that artificially induced ‘Vitória’ pineapple shootss provided fruits with lower biomass and biometric characteristics.

Pulp color and translucency

In relation to the translucent area, a significant difference was found between the ages of floral induction, in which the natural flowering resulted in fruits with a larger translucent area, corresponding to 26 to 50% of translucency in the pulp (Table 3). Since the color of the skin was the criterion used to establish the apparent maturation of the fruit and the so-called “painted” stage was standardized, the results of this work corroborate that the color of the skin is not a good indicator of maturation (THÉ et al., 2010). As a result, the degree of translucency of the pulp is considered to be the best indicator of fruit maturation, that is, based on the translucency of the pulp, a method of evaluation of the real maturation is established. In this type of evaluation, the percentage of the translucent zone is compared to the opaque; fruits with the translucent zone corresponding to 50% of its area, should already have its skin colored (CARVALHO; BOTREL, 1996).

According to Pathaveerat et al. (2008), the translucent area of the pineapple pulp is used as a standard in the evaluation of the degree of maturation of the fruits destined for industry, and its importance is related to both maturation and fruit texture. For Oliveira et al. (2015), translucency is a disorder that promotes water-like appearance with areas of more intense yellow in pineapple pulps.

The color of the skin is strongly influenced by a number of factors related to the cultivar and the environmental conditions (CUNHA, 2003; JOOMWONG; SORNSRIVICHAI, 2005). It was verified that the fruit of the plants induced at 10 months presented a smaller translucent area and when analyzing the weather data (Figure 1), it was verified that they developed for longer periods under the conditions of lower temperature. Therefore, according to Manica (1999), whether the color of the skin is standardized, these fruits tend to be more immature, which would reflect in the lower percentage of translucent area found. On the other hand, Manica (1999) also states that fruits harvested at the same skin color pattern, those with higher biomass tend to have a higher real maturation than smaller fruits. These results were also observed in the present study, in which fruits of later induction presented higher biomass and a higher percentage of translucent area.

Regarding the types of the evaluated shootss, no statistical differences were observed for translucent area. Similar trends were found by Fassinou Hotegni et al. (2015) in studies on fruit quality of different types of 'Smooth Cayenne' pineapple shoots, when they report that the type of planting material had no significant effect on the percentage of translucent area.

The pulp of the fruits whose plants were induced at eight months after planting presented a higher luminosity (L*), not differing from the induction at ten months after planting (Table 3), indicating that the early-induced plants may present fruits of clearer pulp and brighter intensity. Berilli et al. (2014), found values of 64.9 for the luminosity characteristic in naturally induced 'Vitória' pineapple fruits. Similar to that study, a mean of 64.83 was observed in the induction at 12 months, which did not differ from the natural flowering, which was 65.78. The different shoots did not influence the variable.

The color characteristic a* was subject to an interaction between the different types of shoots and ages of floral induction (Table 3), where the lowest values conferred at the induction at eight months after planting of the different shoots. The result shows little expressiveness in the intensity of green and red colors, with intermediate values among them, represented by a little yellowish color. Only with induction at ten months after planting, a significant difference between the types of shoots with the lowest color value a* (1.21) was found in slips fruits.

A lower mean for color characteristic b* was found in fruit with floral induction at ten months after planting, not differing from natural flowering. The variation between the evaluated treatments was at some extent low for color characteristic b*. The values within this range allowed to classify the pulp between a whitish to light yellow, since it was in mediator values between zero (blue) and 70 (yellow), according to classification reported by Carvalho et al. (2016). The color variable b* as well as the darkening index of the pulp, were not influenced by the treatments of the different types of shoots.

However, regarding pulp darkening index, a significant difference ($p \leq 0.05$) was found between the ages of inductions, in which induction at ten months after planting stands out for presenting lower value in relation to the other ages. Andrade et al. (2015) found higher values for the darkening index of 'Vitória' pineapple pulp. In addition, they reported that pulp luminosity may be related to this variable, presenting both inversely proportional effect, a fact observed in the present experiment (induction to 10 and 12 months and in natural)

Chemical variables and pulp yield

For pulp yield, no differences were observed between the types of shoots, but they differed between the ages of floral induction, in which the highest yield was for induction at eight months, which did not differ significantly from the induction at ten months after planting and natural flowering (Table 4). In comparison to the post-harvest quality of pineapple fruits, Andrade et al. (2015), when studying the physical characteristics and conventional management of NPK fertilization, obtained a pulp yield of 74.97% for cultivar Vitória, where a result superior to that found in the present study was verified. It is possible that the result may be explained because the authors consider of complete infructescence (unpeeled fruits) in the percentage of the pulp yield, unlike the present work, which considered the fruits without peel.

In relation to the chemical characteristics, a significant interaction was found between the types of shoots and the ages of floral induction (Table 4). The type of shoots influenced the quality of the fruit only in the naturally induced plants, and the slips, they provided superior characteristics, such as higher ºBrix, lower acidity and a greater ratio. For the induction ages, the result of the chemical quality of the fruit varied according to the type of shoots that was used.

For fruits from the sucker shoots induced at 12 months after planting, a mean of up to 17.32°Brix was observed, with a difference of 23.53% more in the soluble solids content in comparison to the plants induced at eight months. It is important to note that the high climatic conditions where the plants were in formation and maturation of fruits from naturally inductions and inductions at 12 months probably influenced the excellent results of the chemical quality of the fruits. Andrade et al. (2015), when evaluating 'Vitória' pineapple fruits under conventional management harvested at the commercial maturity point, reported values of 3.61; 14.45°Brix; 0.71% and 20.14 for the characteristics of pH, soluble solids, titratable acidity and ratio, respectively.

Regarding evaluations of the quality of 'Vitoria' pineapple, other authors achieved the following values in their studies: 3.6 pH; 16.0°Brix; 0.81 TA (titratable acidity) and 19.80 ratio (BERILLI et al., 2014); 13.3 ° Brix; 0.53 TA and 25.10 ratio (CAETANO et al., 2015) and Silva et al. (2015) found 3.44; 15.42°Brix; 0.82% citric acid and 23.15 for pH; soluble solids; titratable acidity and ratio values, respectively, which are close to those found in the present study.

The highest value for ratio was verified in fruits of naturally induced slips, which also did not differ significantly from each other from the shoots induced at 12 months after planting. Caetano et al. (2007) found similar values (25.1) in fruits of 'Vitória' pineapple shootss induced at 11 months after planting, harvested in June 2008. These results were superior to those verified by Viana et al. (2013), who, when studying the different genotypes of pineapples, found a value of 14.68 for 'Vitoria' pineapple. In addition, the authors emphasize the importance of this variable, highlighting ratio as a quality index related to the sweetness of the fruit, that is, fruits with higher ratio present more pronounced sweetness, and consequently, more preferred by the consumers.

However, although the result of the fruit chemical quality varied according to the type of shoots used in the experiment and the age of induction, a certain pattern could be observed, with a better balance between sugars and acidity in later induced plants, which developed in periods with higher temperatures and sun light, with positive influence on the results. Overall, slip-type shoots, naturally induced at 12 months provided fruits with more adequate balance between soluble solids and acidity, with higher ratio, therefore, more suitable for fresh consumption.

Table 1- Mean values of the biomass of the fruit with and without crown (g), crown biomass (g) and firmness (kgf) of 'Vitória' pineapple fruits, according to shoots types and age of the plant for floral induction. Sooretama, 2015-2016.

	------------------------------ Biomass of the fruit with crown (g) ------------------------------				
Shoots	-------------Age for floral induction ----------------				Means
	8 months Dec/2015	10 months Feb/2016	12 months May/2016	Natural	
Slip (100-200g)	495.61	676.54	774.59	1084.14	757.72 A
Sucker (201-300g)	420.86	493.65	563.19	1105.04	645.69 A
Mean	458.24 c	585.09 bc	668.89 b	1094.59 a	
CV (%)$_{\text{Shoot type}}$			23.14		
CV (%)$_{\text{Induction age}}$			19.19		
	--------------------------------- Biomass of the fruit without crown (g) ----------------------				
Slip (100-200g)	366.62	528.9	636.97	960.9	623.35 A
Sucker (201-300g)	310.53	370.82	478.05	995.14	538.64 A
Mean	338.57 c	449.86 bc	557.51 b	978.02 a	
CV (%)$_{\text{Shoot type}}$			29.01		
CV (%)$_{\text{Induction age}}$			19.02		
	---------------------------------- Crown biomass (g) ------------------------------------				
Slip (100-200g)	128.99	131.59	137.62	123.24	130.36 A
Sucker (201-300g)	110.34	122.83	88.8	109.89	107.97 B
Mean	119.66 a	127.21 a	113.21 a	116.57 a	
CV (%)$_{\text{Shoot type}}$			13.61		
CV (%)$_{\text{Induction age}}$			25.08		
	------------------------------------ Fruit firmness (kgf) -------------------------------------				
Slip (100-200g)	7.54	9.39	11.07	10.22	9.56 A
Sucker (201-300g)	7.69	9.36	10.54	10.09	9.42 A
Mean	7.61 c	9.38 b	10.81 a	10.16 ab	
CV (%)$_{\text{Shoot type}}$			15.58		
CV (%)$_{\text{Induction age}}$			6.87		

Means followed by the same upper-case letter in the column and lower-case letter in the row do not differ from each other by the test of Tukey, at 5% of probability.

Table 2- Mean values of circumference (cm), length (cm), diameter, central cylinder diameter (cm) and pulp thickness (cm) in 'Vitória' pineapple fruits, according to the shoot types and age of the plant for floral induction. Sooretama, 2015-2016.

Shoot	8 months Dec/2015	10 months Feb/2016	12 months May/2016	Natural	Means
Fruit circumference (cm) — Age for floral induction					
Slip (100-200g)	29.83	31.7	31.94	36.31	32.44 A
Sucker (201-300g)	28.49	27.93	29.4	36.21	30.51 A
Mean	29.16 b	29.82 b	30.67 b	36.26 a	
CV (%)$_{\text{Shoot type}}$			7.31		
CV (%)$_{\text{Induction age}}$			7.19		
Fruit length (cm)					
Slip (100-200g)	8.26	9.49	10.92	13.80	10.62 A
Sucker (201-300g)	8.03	8.08	9.79	14.4	10.08 A
Mean	8.15 c	8.79 c	10.36 b	14.10 a	
CV (%)$_{\text{Shoot type}}$			11.78		
CV (%)$_{\text{Induction age}}$			7.05		
Fruit diameter (cm)					
Slip (100-200g)	8.96	9.38	9.25	10.45	9.51 A
Sucker (201-300g)	8.33	8.21	8.44	10.59	8.89 A
Mean	8.65 b	8.80 b	8.84 b	10.52 a	
CV (%)$_{\text{Shoot type}}$			8.16		
CV (%)$_{\text{Induction age}}$			8.73		
Central cylinder diameter of the fruits (cm)					
Slip (100-200g)	1.31	0.90	0.82	0.95	0.99 A
Sucker (201-300g)	1.16	0.76	0.77	0.97	0.91 B
Mean	1.24 a	0.83 c	0.80 c	0.96 b	
CV (%)$_{\text{Shoot type}}$			7.29		
CV (%)$_{\text{Induction age}}$			7.69		
Fruit pulp thickness (cm)					
Slip (100-200g)	3.86	4.34	4.33	5.01	4.38 A
Sucker (201-300g)	3.63	3.87	4.01	4.91	4.10 A
Mean	3.75 b	4.11 b	4.17 b	4.96 a	
CV (%)$_{\text{Shoot type}}$			6.95		
CV (%)$_{\text{Induction age}}$			8.15		

Means followed by the same upper-case letter in the column and lower-case letter in the row do not differ from each other by the test of Tukey, at 5% of probability.

Table 3- Mean values of translucent area (%), color L*, a*, b* and pulp darkening index (%) in 'Vitória' pineapple fruits, according to shoot types and age of the plant for floral induction. Sooretama, 2015-2016.

Shoots	Age for floral induction: 8 months Dec/2015	10 months Feb/2016	12 months May/2016	Natural	Means
Translucent area (%)					
Slip (100-200g)	3.43	2.84	3.87	3.99	3.53 A
Sucker (201-300g)	2.74	2.70	3.10	4.09	3.16 A
Mean	3.08 bc	2.77 c	3.48 b	4.04 a	
CV (%)$_{\text{Shoot type}}$			20.02		
CV (%)$_{\text{Induction age}}$			11.63		
L*					
Slip (100-200g)	74.14	72.95	63.26	67.10	69.36 A
Sucker (201-300g)	77.37	72.51	66.41	64.47	70.19 A
Mean	75.76 a	72.73 a	64.83 b	65.78 b	
CV (%)$_{\text{Shoot type}}$			3.14		
CV (%)$_{\text{Induction age}}$			4.19		
a*					
Slip (100-200g)	0.48 Ac	1.21 Bb	1.66 Aa	1.52 Aab	
Sucker (201-300g)	0.54 Ab	1.67 Aa	1.63 Aa	1.57 Aa	
CV (%)$_{\text{Shoot type}}$			15.63		
CV (%)$_{\text{Induction age}}$			12.30		
b*					
Slip (100-200g)	16.12	12.67	14.47	15.02	14.57 A
Sucker (201-300g)	15.42	13.18	15.54	13.63	14.44 A
Mean	15.77 a	12.93 b	15.01 a	14.33 ab	
CV (%)$_{\text{Shoot type}}$			8.21		
CV (%)$_{\text{Induction age}}$			8.07		
Darkening index (%)					
Slip (100-200g)	20.68	15.96	21.72	21.15	19.88 A
Sucker (201-300g)	19.63	17.01	20.69	19.95	19.32 A
Mean	20.16 a	16.49 b	21.20 a	20.55 a	
CV (%)$_{\text{Shoot type}}$			3.79		
CV (%)$_{\text{Induction age}}$			9.31		

Means followed by the same upper-case letter in the column and lower-case letter in the row do not differ from each other by the test of Tukey, at 5% of probability.

Table 4- Mean values of pulp yield (%), pH, soluble solids (°Brix), titratable acidity (% of citric acid) and ratio (SS/TA) of 'Vitória' pineapple fruits, as a function of shoot types and age of the plant for floral induction. Sooretama, 2015-2016.

Shoots	8 months Dec/2015	10 months Feb/2016	12 months May/2016	Natural	Averages
	------------------------------ Pulp yield (%)				
	------------Age for floral induction --------------				
Slip (100-200g)	46.64	48.02	42.62	42.40	44.92 A
Sucker (201-300g)	49.31	45.7	38.97	42.31	44.07 A
Mean	47.97 a	46.86 ab	40.79 b	42.35 ab	
CV (%)$_{\text{Shoot type}}$			5.59		
CV (%)$_{\text{Induction age}}$			10.13		
	-- pH				
Slip (100-200g)	3.36 Ab	3.33 Ab	3.70 Aa	3.73 Aa	
Sucker (201-300g)	3.33 Ab	3.33 Ab	3.65 Aa	3.57 Ba	
CV (%)$_{\text{Shoot type}}$			0.84		
CV (%)$_{\text{Induction age}}$			1.57		
	-------------------------------- Soluble solids (°Brix)				
Slip (100-200g)	13.30 Ac	15.20 Ab	16.56 Aab	16.96 Aa	
Sucker (201-300g)	13.56 Ac	15.61 Ab	17.32 Aa	15.68 Bb	
CV (%)$_{\text{Shoot type}}$			8.26		
CV (%)$_{\text{Induction age}}$			4.03		
	------------------------- Titratable acidity (% of citric acid)				
Slip (100-200g)	1.11 Aa	1.14 Aa	0.70 Ab	0.75 Bb	
Sucker (201-300g)	1.16 Aa	1.02 Aab	0.86 Ab	1.01 Aab	
CV (%)$_{\text{Shoot type}}$			10.59		
CV (%)$_{\text{Induction age}}$			12.53		
	-- Ratio (SS/AT)				
Slip (100-200g)	12.43 Ab	14.25 Ab	25.34 Aa	26.63 Aa	
Sucker (201-300g)	11.89 Ab	16.26 Aab	21.23 Aa	17.73 Ba	
CV (%)$_{\text{Shoot type}}$			5.98		
CV (%)$_{\text{Induction age}}$			15.84		

Means followed by the same upper-case letter in the column and lower-case letter in the row do not differ from each other by the test of Tukey, at 5% of probability.

Conclusion

Naturally induced fruits presented greater biomass and biometric results for most of the evaluated characteristics.

Regardless of the types of the evaluated shoots, in relation to the planting carried out in April/2015, the fruits originated from later inductions presented a greater firmness, a desirable characteristic for the export of fresh fruit and for the industry of pineapple slices, pieces in syrup and crystallized.

Fruits resulting from their development in periods with higher temperatures, from plants naturally induced at 12 months, achieved higher values for ratio, which is suitable for consumption of fresh fruits.

Acknowledgements

The author of this paper would like to thank Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Capes (Coordination for the Improvement of Higher Education Personnel) for granting a scholarship. To Fundação de Amparo à Pesquisa e Inovação do Espírito Santo – FAPES (Foundation for Support to Research and Innovation of Espírito Santo) for the origin of the experimental resources. To Instituto Capixaba de Pesquisa, Assistência Técnica e Extensão Rural (Capixaba Institute for Research, Technical Assistance and Rural Extension), for the collaboration and granting the space.

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