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EVALUACIÓN DEL COMPORTAMIENTO FÍSICO, QUÍMICO, MICROBIOLÓGICO Y SENSORIAL EN RACIMOS Y BAYAS DE UVAS DURANTE DIFERENTES TEMPERATURAS DE ALMACENAMIENTO

EVALUATION OF THE PHYSICAL, CHEMICAL, MICROBIOLOGICAL AND SENSORY BEHAVIOR OF GRAPE BUSHES AND BERRIES DURING DIFFERENT STORAGE TEMPERATURES

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RESUMEN: La uva de mesa es considerada como un rubro no tradicional en la región litoral del Ecuador donde su fruto es altamente perecedero y cuya calidad post cosecha depende de condiciones de almacenamiento, especialmente de la temperatura. En la provincia de Santa Elena, donde el cultivo de la vid ha aumentado significativamente en los últimos años, aún mantiene limitaciones técnicas en el manejo post cosecha que afectan la vida útil. En este estudio se analizó el comportamiento físico, químico, microbiológico y sensorial de las variedades Red Glove e Ivory, almacenadas en diferentes temperaturas de almacenamiento (0 °C, 4 °C, 10 °C y al ambiente), durante un periodo de 20 días. Las muestras fueron adquiridas un mercado local de Santa Elena empleando un análisis experimental al azar con arreglo factorial. Se evaluaron variables como pérdida de peso de racimos y bayas, pH, sólidos solubles totales (Brix), acidez titulable, índice de madurez, recuento de aerobios mesófilos y análisis sensorial. Los resultaron indicaron que el almacenamiento a 0 °C permitió disminuir la pérdida de peso, ralentizar los procesos de maduración y mejorar su estabilidad microbiológica en ambas variedades. La variedad Red Glove presentó un comportamiento más estable a esta temperatura, mientras que Ivory mostró mayor deshidratación del racimo, aunque con menor pérdida de peso en sus bayas. Se concluye que el manejo adecuado de la temperatura a 0 °C, es crucial para asegurar la vida útil de la uva de mesa de Santa Elena, por lo que es relevante mejorar la cadena de frio para mejorar la calidad e inocuidad del producto.

Palabras clave: *bayas, racimo, uva, postcosecha, temperatura*

ABSTRACT: Table grapes are considered a non-traditional crop in the coastal region of Ecuador, where the fruit is highly perishable and its post-harvest quality depends on storage conditions, especially temperature. In the province of Santa Elena, where grape cultivation has increased significantly in recent years, technical limitations in post-harvest handling still affect shelf life. This study analyzed the physical, chemical, microbiological, and sensory behavior of the Red Glove and Ivory varieties, stored at different temperatures (0 °C, 4 °C, 10 °C, and ambient) for 20 days. Samples were acquired from a local market in Santa Elena using a randomized, factorial design. Variables evaluated included bunch and berry weight loss, pH, total soluble solids (Brix), titratable acidity, maturity index, mesophilic aerobic count, and sensory analysis. The results indicated that storage at 0°C reduced weight loss, slowed ripening processes, and improved microbiological stability in both varieties. The Red Glove variety exhibited more stable behavior at this temperature, while Ivory showed greater bunch dehydration, although with less berry weight loss. It is concluded that proper temperature management at 0°C is crucial to ensuring the shelf life of Santa Elena table grapes, making it essential to improve the cold chain to enhance product quality and safety.

Keywords: *Berries, bunch, grape, postharvest, temperature*

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INTRODUCTION

The introduction of the grapevine on the American continent occurred during the period of European colonization, consolidating subsequently in countries with temperate climatic conditions and marked seasonality (1). In this context, Argentina and Chile position themselves as the principal producers of grapes in South America, standing out for their high technological level, efficient management systems, and consolidated value chains that permit them to compete in international markets (2).

Although Ecuador has not been recognized as a wine-producing country, recent studies and productive experiences evidence that the cultivation of the grapevine possesses a high potential, especially in the provinces of Santa Elena and Loja, owing to their favorable edaphoclimatic conditions (3). In the case of the province of Santa Elena it presents climatic conditions that permit obtaining up to two annual harvests, which represents a significant competitive advantage compared with other producing countries of the region (4).

According to data of the Association of Grape Producers of Ecuador (APRUEC), the cultivation of the grapevine has been gaining space within the productive activities of the province of Santa Elena, traditionally dominated by fishing and tourism (5). In the year 2019, the national production of grapes reached approximately 3.93 million kilograms, concentrated principally in two agricultural enterprises, Pura Vida and Dos Hemisferios. Nevertheless, this production proves insufficient to cover the internal demand, which surpasses 28 million kilograms annually, generating a high dependence on importation (6).

Faced with this gap between supply and demand, the producers have posed as strategic vision the expansion of the sowing areas of the grapevine crop. Currently, in the province of Santa Elena around 38 cultivated hectares are registered, with projections of expansion up to 90 hectares, which would permit incrementing the production by approximately 40% (5). However, this productive growth is conditioned by certain technical limitations, especially in what is related to the management of the crop and, in a critical manner, with the postharvest processes (7).

Diverse authors coincide in that one of the principal factors that affect the competitiveness of table grapes in Ecuador is the limited technical training of the small

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and medium producers in the stages of harvest, postharvest, storage, and commercialization (8). Postharvest constitutes a determining phase, since from it depends that the fruit conserve its organoleptic quality, safety, and shelf life until reaching the final consumer (9).

In the provinces of Santa Elena and Loja, where the major production of grapes of the country is concentrated, deficiencies are still evidenced in the application of adequate techniques of manipulation of the bunches, temperature control, conservation, and storage. These techniques, which have been widely studied and developed in traditional producing countries, are still found in phase of adaptation in the Ecuadorian context, which occasions postharvest losses, deterioration of the quality of the fruit, and affectation of its commercial value.

Among the principal postharvest problematics of table grapes are found the rotting of the bunch and the dehydration of the rachis, phenomena associated both to an inadequate management during the phenological development and to inappropriate storage conditions (10). These losses not only affect the profitability of the producer, but also limit the positioning of the national product compared with the imported grape.

Despite these limitations, the cultivation of the grapevine represents a strategic opportunity for the agricultural development of Ecuador. The grape possesses a high nutritional value owing to its content of vitamins, tartaric acid, and polyphenols, compounds with recognized antioxidant capacity and protective effects against damaging cellular processes (11). These characteristics increment its attractiveness in markets that value functional and healthy foods.

The experience of the first vineyard established in the country demonstrates that it is possible to produce table grapes of quality comparable to the imported. The trials realized with varieties such as Red Globe, Ivory, and Arra 15 have generated favorable results, reinforcing the technical viability of the crop (1). In equal manner, the national harvest is realized in months in which countries such as Chile and the United States do not produce, generating strategic commercial opportunities for the Ecuadorian product.

In this context, the present experimental investigation is oriented to broaden the knowledge on the postharvest life of two varieties of table grapes, Red Globe and Ivory, cultivated in the zone of Santa Elena, specifically in the sector San Juan del Morro. The study evaluates the physical, chemical, microbiological, and sensory behavior of these varieties under different storage temperatures, with the aim of generating technical information that contributes to the reduction of postharvest losses and to the improvement of the quality of the product. Finally it is hypothesized that the postharvest storage of the fruits at 0 °C can minimize the degradation of phenolic components, loss of firmness, and variation in the coloration of the berries in relation with those stored at 4 °C.

MATERIALS AND METHODS

Characterization of the grapes

The bunches and berries of table grapes of the varieties Red Globe and Ivory were characterized, before and after being stored. In both stages the behavior of the bunches and berries was evaluated during 20 days with three different temperatures, including the control with ambient temperature (0 °C, 4 °C, 10 °C, and control), this with the purpose of avoiding that the fruit suffer any physical, chemical, and microbiological damage during its transportation.

The grapes were obtained from the market of the province of Santa Elena, in the proximities of the commune El Azúcar, located to the south of the province. The samples were selected randomly and transferred to the laboratory for their analysis.

Analytical determinations: physical, chemical, microbiological, sensory

Physical determinations

These determinations were realized with variations of weight for each sample of bunches and berries, and difference of degrees Brix in berries during the days 5, 10, 15, and 20. The weight loss was calculated based on equation 1:

$$\Delta M = ((m0 - mt) / m0) \times 100$$

Where ΔM is variation of weight in grams in a given time; mt is the weight of sample at the end in grams, and m0 is the initial weight of the sample in grams.

The measurement of degrees Brix was through a refractometer of scale 0 to 90% (ATC, Zuzi.HPD010, Vidrafoc, China).

Coloration of bunches and berries

The coloration of the bunch was determined visually at the moment of storage, defining four categories: dark red (1), red (2), light red (3), and poor color with presence of green berries (4) for the variety Red Globe; and for Ivory the coloration scale was Green (1), Green to Amber (2), Amber to Green (3), Amber (4).

Chemical determinations

The chemical characteristics determined were of pH, titratable acidity, and maturity index, evaluated periodically during 20 days.

For the pH a pH-meter with buffer substances was utilized (PH-02 Lite, Biomed instruments, China). For the acidity a solution of sodium hydroxide was necessary and the data were calculated on the basis of equation 2:

$$Acidity = (V \times C \times F) / M$$

Where V is the volume of the sodium hydroxide consumed during the titration; C is the molarity of the sodium hydroxide; F is the conversion factor of acidity of the tartaric acid; and M is the mass of the grape juice analyzed.

On the other hand, the maturity index was calculated with equation 3 to determine the concentrate of tartaric acid that there is in the fruit.

Microbiological determinations

The microorganisms analyzed were mesophilic aerobes, applying the technical standard NTE INEN 1529-5:2006 Microbiological control of foods. Determination of the quantity of mesophilic aerobic microorganisms.

These analyses were realized by a certified food laboratory employing 500 grams of each variety of grape stored at three temperatures (0, 4, 10 °C) and the control (ambient temperature).

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Sensory analysis

The sensory evaluation was realized with fifteen untrained individuals, the first and fifteenth days. The surveyed oscillated between 20 to 30 years of age, among men and women, all have been accustomed to tasting the grapes of both varieties. The survey was of five-point hedonic scale, being 5 I like very much, 4 I like a lot, 3 I like, 2 I do not like much, and 1 I do not like. The parameters of the characteristics of the fruit evaluated were: flavor, color, form, size, juiciness, seed, and skin, which were represented with a radial diagram by variety.

Deduction of the postharvest shelf life

In order to determine the postharvest shelf life in the two varieties of table grapes the temperature, the relative humidity, the management conditions were evaluated, avoiding mechanical damages and the presence of microorganisms. It was stored at temperatures of 0, 4, and 10 °C.

The present investigation in grapes employed a high relative humidity (90–95 %) to help prevent the dehydration and the wilting of the fruit and loss of shelf life. The grape was monitored avoiding the growth of fungi, especially Botrytis cinerea.

Statistical analysis

The data of differences of weight of the bunch and berries and Brix of berries obtained from the first until the twentieth day were analyzed by Tukey (ANOVA) with a level of significance (P-value < 0.05), through the program INFOSTAT student version, taking into account the variables of storage temperature and the two varieties of grapes.

RESULTS

Analytical determinations: physical, chemical, microbiological, sensory

Physical determinations

A. Variations of bunch weight

In the variations of weights of the grape bunches that surpassed 222 grams of loss, it presented for the variety Ivory at 4 °C; this could be due to the dehydration that is produced at this temperature, as well as to the relative humidity and to the time of storage in which it was exposed (see Table 2).

The analysis of variance of the means of data corresponding to the weight of the bunch on the first day, gave a coefficient of variation (CV) 36.58%; it is necessary to remember that logarithmic transformation technique was applied, therefore the CV changed to 6.85%. Among the means, the highest valuation obtained was Ivory 4 °C 566 g, followed by Red Globe 0 °C 544.33 g, and finally the Ivory Control with a lower mean 262.67 g.

On the fifth day, upon weighing the bunches, a coefficient of variance of C.V 37.35% was obtained; with the transformation of values it arrived at 7.00%. However, no significant differences were found; the highest value of the mean resulted for Red Globe 0 °C 540 g, and Ivory 4 °C 528.67 g, being the lowest mean for Ivory Control 246.33 g.

On the tenth day, the CV was very elevated of the range 38.19%, for which a transformation technique (Log 10) was applied, changing to a normal coefficient 7.19%, without finding significant differences. The variety Red Globe 0 °C obtained higher valuation 529.33 g, and the Ivory Control with lower mean 232.33 g.

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On the fifteenth day, the CV was very high 38.82% for which with the transformation of Log 10 it was managed to lower it until 7.40%, determining that no significant differences were found. The valuations of high mean was for Red Globe 0 °C 519.67 g, contrary to Ivory Control with low mean 222. Arriving at the twentieth day, the CV was of 7.36% being within the established range, for which no significant differences were found. The high mean was for Red Globe 0 °C 500.67 g, and low mean for Ivory Control 210 g.

B. Variations of berry weight

With respect to the variations of weight in berries, from the first day its behavior was very similar in both varieties, being the Ivory the one that registered weight a little low. Until the last day, the Red Globe at 0 and 10 °C and Ivory 0 °C lost ≥ 4 grams (see Table 1).

With respect to the analysis of variance, for the first day the CV was 15.75%, without showing significant differences in means. The highest value of mean was for Red Globe 0 °C 10.67 g, and the lowest for Ivory 4 °C 7.33.

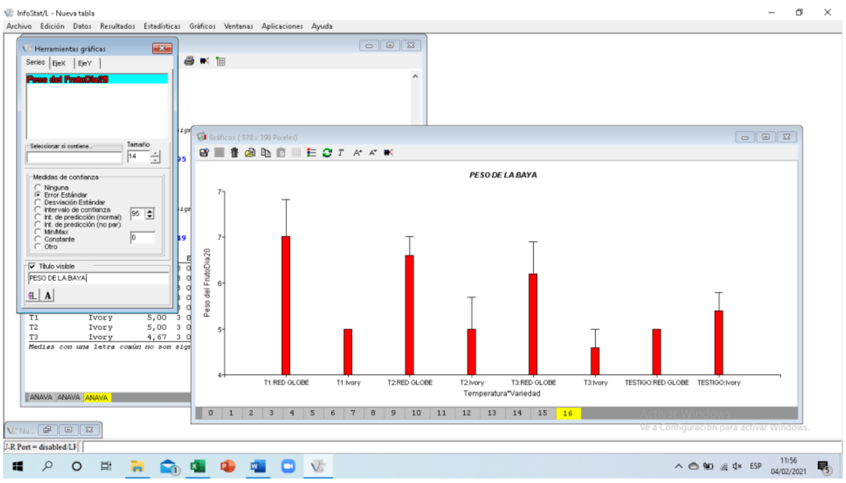
For the fifth day the CV was 9.38%, the data indicate significant differences in the different temperatures, being the highest value of mean for Red Globe 0 °C 10 g, and the lowest value for Ivory 4 °C 6.75 g.

The CV for the tenth day was of 13.93%, being the highest value of mean for Red Globe 0 °C 10 g, and the lowest value for Ivory 4 °C 5.67 g. The fifteenth and twentieth days, the CVs were 15.07% and 13.38% respectively. The values of higher means were for Red Globe 0 °C 7.67 and 6.67 g, and lower for Ivory 5.33 g and Ivory 10 °C 4.67 g respectively.

Table 1. Averages of weight losses of bunch and berries of two varieties of grapes and three storage temperatures.

Full numerical data for bunch and berry weight losses across days 1, 5, 10, 15 and 20 for Red Globe and Ivory at 0 °C, 4 °C, 10 °C and ambient control are presented in the original source Table 1. Key observed trends: Red Globe at 0 °C retained the highest bunch weights throughout; Ivory at 4 °C showed the highest initial bunch weight but greater subsequent dehydration; berry weight losses were lowest at 0 °C for both varieties.

Figure 1. Statistical graphs of averages of weight losses in bunch and berries of two varieties of grapes at different storage temperatures.



C. Degrees Brix

On the other hand, the degrees Brix showed values that increased with temperature and time of storage, reflecting the concentration of sugars associated with progressive

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dehydration of the berries. The highest Brix values were recorded in the Ivory variety at intermediate and higher temperatures.

Coloration of bunches and berries

Visual coloration progressed according to the temperature regime. At 0 °C the color changes were slower; at higher temperatures and ambient conditions the appearance of fungal growth (Botrytis cinerea) was observed from day 15 onward.

Figure 3. Visual coloration of Ivory and Red Globe at 0 and 4 °C. A. First day; B. Fifth day; C. Tenth day; D. Fifteenth day; E. Twentieth day.

Chemical determinations

A. pH – For the evaluation of the pH of the variety Ivory 4 °C a value of 4.26 of pH was given being the highest value of the evaluation; in the variety of the Red Globe 0 °C a pH of 3.92 was given being the highest value of its variety. The variety of Red Globe 10 °C obtained 3.04 of pH being this the lowest value.

B. Titratable acidity – The evaluation of titratable acidity of the variety Ivory 0 °C obtained 1.18% being the highest valuation, followed by the variety Red Globe 4 °C with a titratable acidity of 1.16%. The variety of Red Globe 10 °C and 0 °C with 0.57 and 0.58% obtained lower values of titratable acidity.

C. Maturity – The Brix of the treatments were considered for the data of maturity index; the variety that obtained higher index was the Ivory 10 °C with 34.99%, followed by the Ivory 4 °C with 34.42%. Likewise, the varieties with lower maturity indices were the Red Globe with 15.56% followed by the Ivory 0 °C with 18.60%.

Table 3. Averages of chemical determinations.

Key values from Table 3: Red Globe 0 °C – pH 3.92, Brix 15, titratable acidity 0.58, maturity index 26.01; Ivory 0 °C – pH 4.19, Brix 22, titratable acidity 1.18, maturity index 18.60; Ivory 4 °C – pH 4.26, Brix 24, maturity index 34.42; Ivory 10 °C – maturity index 34.99. Full titration data are retained in the original source.

Microbiological determinations

The samples of Red Globe 4 and 10 °C presented in the microbiological results values <10 CFU/g which indicated absence of microorganisms in a dilution of 1/10. In the Red Globe and Ivory with the temperature of 0 °C there existed presence of mesophilic

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aerobes 3×10 CFU/g; for the variety Ivory 4 °C a count of mesophilic aerobes of 4×10 was given. The Ivory 10 °C and the Control obtained results of count of mesophilic aerobes superior in comparison with the other samples.

Table 4. Analysis of Aerobes and Mesophiles.

Results (CFU/g): Red Globe 0 °C = 3×10; Ivory 0 °C = 3×10; Red Globe 4 °C = <10; Ivory 4 °C = 4×10; Red Globe 10 °C = <10; Ivory 10 °C = 2×10^2; Red Globe Control = 3×10^2.

Sensory analysis

On the first day, the variety Red Globe obtained higher acceptability in the parameters evaluated, of flavor, color, form, size and the juiciness with maximum valuation, followed by the parameters of seed and skin. Likewise the evaluation of parameters of the Ivory resulted to be very acceptable with valuation of 5 (I like very much) in color, flavor, seed and the juiciness, followed by the size, skin and form with qualification of 4 (I like a lot).

On the fifteenth day, the parameter of the seed was the best evaluated, in both varieties, more than 88% of the surveyed decided that they like a lot and to 13% they like very much the Red Globe, and to 100% they like very much the seed of the Ivory.

Other parameters well qualified (≥ 4) especially for the Ivory were the juiciness and flavor, followed by the skin and form. For Red Globe the parameters of skin, juiciness, flavor, size and form remained generally acceptable, while color showed some decline.

Figure 4. Radial graph of the Red Globe and Ivory on the first and fifteenth day.

Deduction of the postharvest shelf life

Coefficients of variation (CV) superior of 40% were obtained for the variables of the weight of the bunch, Degrees Brix and the weight of the berry. For which the assumptions of normality for the described variables were applied determining that the variables possess a normal distribution and equality of variances of the data evaluated, for which the technique of data transformation according to Log 10 was applied.

DISCUSSION

The storage temperature demonstrated to be a determining factor in the conservation of the postharvest quality of the table grapes, influencing in a direct manner on the physical, chemical, microbiological, and sensory variables evaluated. These results concur with what was reported in the literature, where it is established that the adequate thermal management is key to prolong the shelf life of the grape and to reduce the postharvest losses (9,12,17).

The greater dehydration of the bunch observed in the variety Ivory stored at 4 °C can be attributed to the susceptibility of the rachis to the loss of water under conditions of inadequate relative humidity, more than by a phenomenon directly associated to the berry. Previous studies indicate that the dehydration of the rachis is the most sensitive tissue to the hydric stress, that is to say one of the principal factors that affect the commercial appearance of the bunch; even they indicate that the loss of turgor of the rachis is closely related with the environmental hydric deficit and with the interruption of the flow of water toward the berries after the harvest; upon interrupting the vascular flow, the rachis acts as a surface highly exposed to the transpiration, especially when parameters such as the relative humidity are little controlled (10,18). In this sense,

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although the variety Ivory presented fragility in the bunch, its berries showed lower loss of weight than those of Red Globe, which suggests structural differences in the cuticle and in the permeability of the epidermis, as has been described by Crisosto and Kader (13). This behavior suggests that the dehydration concentrates in the rachis and not in the fruit, that is to say that the wilted appearance of the rachis can present itself even when the berries conserve their turgor.

Likewise, Keller (18) mentions that there are varietal differences in the body of the rachis, in a particular manner in the diameter of vascular bundles, thickness of parenchymatic tissues and in the capacity of retention of water, for which these structural differences can explain why this variety Ivory has a rachis with greater postharvest dehydration.

As was mentioned, in the case of the Ivory the rachis is the predominant factor and not the stomatal density of the berry; the rachis has a thinner cuticle and a greater exposure to the environment than the berry; thus also the dehydration of this causes a great visual impact on the quality of the bunch even when the berries do not register significant losses of weight; however, the results varied with respect to the variety Red Globe in berries (13,14).

On the contrary, the variety Red Globe evidenced a greater loss of weight in the berries during the storage, especially at temperatures superior to 0 °C. This behavior has been widely associated to the transpiration and respiration of the fruit, processes that intensify as the storage temperature increases (9,19). It is necessary to take into account that the grape berries upon possessing few functional stomata, lose activity as the maturation advances; upon occurring this the loss of water in the berry could be by diffusion through the cuticle or by microfissures in the epidermis. This leaves us open to think that the cuticle of the Ivory could be thicker or less permeable reducing the loss of water. The loss of water in the berries keeps direct relation with the increment of the total soluble solids, reflected in the increase of the degrees Brix, phenomenon that has been reported as an effect of concentration of sugars due to the partial dehydration of the fruit (14).

The increment of the degrees Brix and of the maturity index observed in the variety Ivory stored at 10 °C coincides with what was indicated by Valverde et al. (15), who indicate that intermediate temperatures can accelerate the metabolic processes, promoting the degradation of organic acids and the relative increase of sugars (15). However, although a higher maturity index can improve the sensory perception of the flavor, it can also compromise the shelf life of the product especially if it is accompanied by greater microbial activity. Nevertheless, this process can compromise the stability of the fruit, since an accelerated maturation usually goes accompanied by a greater susceptibility to the physiological and microbiological deterioration (20).

From the microbiological point of view, the storage at 0 °C showed better conditions of stability, upon registering lower counts of mesophilic aerobes in both varieties. This result is consistent with what was reported by Cantín et al. (16), who indicate that the low temperatures inhibit the microbial growth and delay the development of postharvest pathogens such as Botrytis cinerea (16). In addition, the more acid pH registered in the treatments at 0 °C contributed to limit the proliferation of

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microorganisms, since values of low pH generate an environment less favorable for the bacterial and fungal proliferation in the table grape (21).

The appearance of fungi from the fifteenth day of storage confirms that, even under refrigeration, the grape is a highly perishable fruit and susceptible to the microbiological deterioration if a constant cold chain and optimal conditions of relative humidity are not maintained. These findings reinforce the necessity of implementing postharvest management technologies adapted to the local conditions of Ecuador, where the losses by microbial deterioration continue being elevated.

With respect to the sensory evaluation, the results evidenced a general positive acceptability for both varieties, especially in the parameters of flavor and juiciness. However, the deterioration of the color and the external appearance of the bunch, principally in the variety Ivory, influenced negatively in the perception of the consumer toward the end of the period of storage. Diverse authors coincide in that the color, the integrity of the bunch and the absence of visible rots are decisive factors in the commercial acceptance of the table grape (22).

Taken together, the results obtained confirm that the storage at 0 °C constitutes the best alternative to conserve the postharvest quality of the varieties Red Globe and Ivory in the conditions evaluated. These findings contribute relevant information for the strengthening of the productive chain of the grape in the province of Santa Elena, contributing to the reduction of postharvest losses and to the better positioning of the national product compared with the imported grape.

CONCLUSIONS

The storage temperature influenced as the most determining factor in the postharvest behavior for the conservation of the varieties Ivory and Red Globe, managing to influence directly in the loss of weight, the physicochemical changes such as retarding the processes of maturation, and maintaining the microbiological integrity and the sensory acceptability. The storage at 0 °C permitted reducing significantly the dehydration, retarding the metabolic processes associated to the maturation and limiting the microbial development, which translated into a greater general stability of the fruit during the 20 days of evaluation. These results evidence that the adequate thermal management constitutes a key tool to prolong the shelf life of the table grape produced in the province of Santa Elena.

Relevant varietal differences were identified in the postharvest behavior of the grapes evaluated. The variety Red Globe presented a greater stability of the bunch and of the berries, with lower losses of weight and lower values of pH, which favored its microbiological conservation. In contrast, the variety Ivory showed a greater dehydration of the bunch, particularly at 4 °C, although its berries presented lower loss of weight. This behavior suggests that the dehydration observed in Ivory is principally associated to the structural susceptibility of the rachis and not to a greater loss of water in the berry, which highlights the importance of considering specific anatomical and physiological characteristics of each variety in the design of postharvest management strategies.

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The changes in the total soluble solids, the titratable acidity and the maturity index evidenced that temperatures superior to 0 °C favor the concentration of sugars and accelerate the maturation, which can improve temporarily the sensory perception, but compromises the stability of the fruit and its shelf life. Likewise, the appearance of fungi and the increment of the count of mesophilic aerobes in treatments at more elevated temperatures and in the control confirm the high perishability of the table grape and the necessity of strengthening the cold chain. Taken together, the results obtained contribute relevant technical information to optimize the postharvest management of the grape in Santa Elena, contributing to the reduction of losses, to the improvement of the commercial quality and to the strengthening of the national production compared with the imported grape. A bad manipulation accelerates the mechanical damage, the respiratory rate and reduces significantly the shelf life of the fruit. The initial quality of the fruit at the moment of the harvest also influences directly in its conservation.

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DECLARATION OF INTEREST

The authors confirm the absence of conflicts of interest of financial, academic or personal nature that have affected the design, the results or the writing of this scientific article.

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