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Effect of storage temperature on physicochemical, physical, microbiological, and sensory characteristics of table grapes (‘Red Globe’ variety)

Efeito da temperatura de armazenamento nas características físico-químicas, físicas, microbiológicas e sensoriais de uvas de mesa (variedade ‘Red Globe’)

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This study assessed the quality attributes and consumer acceptability of ready-to-eat ‘Red Globe’ table grapes from Chile and sold in the Portuguese market. The grapes were stored under different temperatures: refrigerated (T= 5 ± 1 °C) and room temperature (T= 22 ± 1 °C). Physicochemical, physical, chromatic, microbiological, and sensory analyses were conducted at 0, 7, 14, and 21 days of storage. During storage, grapes kept at room temperature had a higher weight loss (28.55 %) compared to those stored under refrigeration (17.05 %). The initial 16.9 °Brix value increased to 18.4 and 21.5 °Brix for grapes stored under refrigeration and at room temperature, respectively. Total acidity, as well as chromatic parameters L*, a*, and b*, remained relatively stable over time, regardless of the storage conditions. Regarding microbiological aspects, table grapes stored under refrigeration maintained satisfactory values for consumption even after 21 days of storage in the laboratory. Grapes stored at room temperature exhibited high mold populations only after 7 days of storage. At the sensory evaluation, refrigerated grapes received a hedonic rating of "liked" (≥ 6) for several sensory parameters. With this study it was possible to demonstrate the importance of the storage temperature of table grapes in the maintenance of their quality and acceptability by consumers.
Keywords: imported table grapes, storage conditions, Portuguese market.

Este estudo avaliou os atributos de qualidade e a aceitabilidade de uvas de mesa ‘Red Globe’ prontas para consumo, provenientes do Chile e comercializadas no mercado português. As uvas foram armazenadas sob diferentes temperaturas: refrigeradas (T= 5 ± 1 °C) e em temperatura ambiente (T= 22 ± 1 °C). Foram realizadas análises físico-químicas, físicas, cromáticas, microbiológicas e sensoriais nos dias 0, 7, 14 e 21 de armazenamento. Durante o armazenamento, as uvas mantidas em temperatura ambiente apresentaram maior perda de massa (28,55 %) em comparação com as armazenadas sob refrigeração (17,05 %). O valor inicial do índice de refração aumentou de 16,9 °Brix para 18,4 e 21,5 °Brix para as uvas armazenadas sob refrigeração e em temperatura ambiente, respectivamente. A acidez total, assim como os parâmetros cromáticos L*, a* e b*, mantiveram-se relativamente estáveis ao longo do tempo, independentemente das condições de armazenamento. Quanto aos aspectos microbiológicos, as uvas de mesa armazenadas sob refrigeração mantiveram valores satisfatórios para consumo, mesmo após 21 dias de armazenamento em laboratório. As uvas armazenadas em temperatura ambiente apresentaram alto crescimento fúngico após 7 dias de armazenamento. Na avaliação sensorial, as uvas refrigeradas receberam uma classificação hedônica de "gostei" (≥ 6) para vários atributos sensoriais. Com este estudo, foi possível demonstrar a importância da temperatura de armazenamento das uvas de mesa na manutenção de sua qualidade e aceitabilidade pelos consumidores.
Palavras-chave: uvas de mesa importadas, condições de armazenamento, mercado português.

1. INTRODUCTION

Grapes are widely cultivated in various regions around the world. They have high nutritional value and are a rich source of bioactive molecules, potentially meeting consumer demands for functional foods. Fresh grapes (*Vitis vinifera* L.) are known for their health benefits attributed to their high content of vitamins, minerals, lipids, fibers, and phenolic compounds [1]. The 'Red Globe' variety is one of the most widely cultivated and commercially important grape varieties [2], gaining popularity among consumers due to its sensory characteristics that appeal to consumers [3, 4]. Sensory attributes play a crucial role in determining fruit acceptability and consumer preferences of fresh fruits significantly influence their commercial success [5, 6].

Grapes are non-climacteric fruits with low physiological activity and rapid senescence [7]. The rate of degradation depends on factors such as temperature, relative humidity, and post-harvest treatments. To extend the shelf life and preserve the quality of table grapes, low temperatures are essential.

Table grapes are typically stored under refrigerated conditions after packaging and consumed raw [8, 9]. However, incidences of microbial contamination, changes in the chemical composition and sensory characteristics of grapes are a concern during transport and commercialization, especially when the fruits are produced in regions far from the consumer. These challenges contribute to significant economic losses for the grape industry [10].

Several studies in the literature have focused on evaluating the characteristics of table grapes immediately after harvest and on developing treatments aimed at extending their shelf life. For example, Godana et al. (2022) [6] assessed the sensory properties of 'Red Globe' table grapes treated with the yeast *Pichia anomala*, alone or in combination with chitosan (1% w/v), under two different storage conditions: refrigerated (T = 4 °C) and at room temperature (T = 20 °C), over a 30-day storage period. Cold storage and yeast treatment resulted in table grapes with higher acceptability in terms of sensory attributes, even after an extended storage period. Furthermore, the percentage of natural decay, berry weight loss, titratable acidity, total soluble solids, berry firmness, and vitamin C content were also evaluated, and the combination of treatment and refrigeration contributed to extended shelf life and enhanced grape quality [6]. Furthermore, with a primary focus on storage temperature, Mattiuz et al. (2009) [11] evaluated the weight loss, appearance, color, soluble solids (SS) and titratable acidity of 'BRS Clara', 'BRS Linda', and 'BRS Morena' table grape varieties cultivated in Brazil. These grapes underwent minimal processing and were stored under refrigeration (T= 12 °C) and at room temperature (T= 24 °C). Refrigerated storage better preserved the grapes compared to room storage [11]. In the context of fresh fruit exports, Goedhals-Gerber et al. (2024) [12] evaluated the critical points of refrigerated containers during the export of table grapes from South Africa to the United Kingdom, identifying that the most severe temperature deviations occur between the removal from cold storage and the loading into the container, and highlighting the need for improvements in the cold chain during export to prevent quality losses.

However, despite the existence of numerous studies on the application of different treatments to table grapes aimed at extending their shelf life, on the effect of storage temperature, and on international transportation conditions, no studies were found in the literature addressing the characterization of 'Red Globe' table grapes imported from Chile and commercialized in Portugal, nor the effect of different storage temperatures on their physicochemical, microbiological, and sensory quality, simulating real conditions of the local market and domestic storage following importation and retail purchase.

Therefore, the aim of this study was to evaluate the effect of storage temperature on the quality of ready-to-eat 'Red Globe' table grapes imported from Chile and marketed in the Portuguese market. The findings provide valuable insights that may contribute to a better understanding of the characteristics of imported table grapes and guide commercial practices aimed at minimizing post-import losses while ensuring consumer satisfaction from the point of sale to domestic consumption.

2. MATERIAL AND METHODS

2.1 Material

'Red Globe' table grapes, with an average berry diameter of 24 mm, ready for consumption, were obtained from a local market in Viseu, Portugal. These grapes were imported from Chile, where were harvested on April 17, 2022, and treated with sulfites by the producer. The analyses in this study started on May 26, 2022 (39 days after harvest). The grapes received in the laboratory were stored under two conditions: refrigeration (T= 5 ± 1 °C) and room temperature (T= 22 ± 1 °C) for 21 days. The sampling was conducted at pre-established intervals upon reception in the laboratory (0, 7, 14, and 21 days), and storage temperatures were defined based on previous studies by Godana et al. (2022) [6] and Konuk Takma and Korel (2017) [13], with some modifications.

Analytical grade reagents were used for all analyses.

2.2 Physicochemical and physical analyses

Weight loss was determined by calculating the percentage difference between the initial and final masses of the berries. The pH was measured using the Hanna Instruments Model HI 84520 Titratable total acidity equipment (USA). Total acidity, expressed as g tartaric acid/L, was determined by titrating the diluted sample (10 mL of grape must extracted in 30 mL of distilled water) with NaOH (0.1 mol/L).

Total soluble solids were determined using the Atago Model IR Brix Meter PAL-HIKARI equipment (Japan) and expressed in ° Brix. Color values (CIE L*, a*, and b*) of eight grape berries were measured at three different equatorial positions using a Minolta colorimeter (Konica Minolta Chroma Meter Model CR-400H, Japan).

All analyses, except for color, were performed in duplicate.

2.3 Microbiological analyses

Microbial analyses were performed on grape berries stored under different conditions in the laboratory, following established protocols [14]. Six grape berries were macerated for 2 min, and serial dilutions were prepared. Mesophilic aerobic bacteria were counted using the pour plate method, with 1 mL of each dilution aseptically inoculated in Petri dishes containing Plate Count Agar (PCA Agar) and incubated in an inverted position at 30 °C for 96 hours. Molds and yeasts were counted using the spread plate method on Sabouraud Glucose Agar (SAB). For this, 0.5 mL of each dilution was aseptically inoculated on Petri plates containing solidified SAB Agar and incubated in an inverted position at 25 °C for 96 hours. The mold and yeast colonies were observed and analyzed using an optical microscope (Leica CME, Germany).

2.4 Sensory analysis

Only samples meeting the microbiological criteria set by the September 2019 Guidelines from the National Institute of Health Dr. Ricardo Jorge (INSA), Portugal, were subjected to sensory evaluation [15]. Sensory analysis was conducted in IPV, following ISO Standard 11136:2014 recommendations and complied with ethical regulations of the IPV and Portugal, including Decree-Law 80/2018. The research was explained to volunteer participants from the Agrarian School of Viseu. Afterwards, they completed a recruitment questionnaire, and nine untrained individuals aged 18 years or older, who liked and frequently consumed table grapes, were selected. The samples (~10 g), cleaned and prepared as a ready-to-eat, were presented individually in transparent plastic cups with blinding codes. The sensory analysis followed the method described by Konuk Takma and Korel (2017) [13], with some modifications. Panelists rated the samples using a nine-point hedonic scale (1 = extremely disliked, 5 = neither liked nor disliked, 9 = extremely liked) for appearance, color, odor, texture, sweetness, acidity, and overall quality.

2.5 Statistical Analysis

The collected data were subjected to one-way analysis of variance (ANOVA) and significant treatment effects over storage time were compared using the Tukey mean comparison method at a 5% probability level ($p < 0.05$). A *t*-test ($p < 0.05$) was used to compare the two storage conditions at each storage time. The data were analyzed using STATISTICA software version 13.0 (Stat Soft Inc., Tulsa, USA).

3. RESULTS AND DISCUSSION

3.1 Physicochemical and physical analyses

Table 1 presents the results for weight loss, pH, total acidity, refractive index, and color of the samples.

Table 1: Physicochemical and physical analysis results of 'Red Globe' table grapes stored under controlled laboratory conditions: refrigeration temperature (T= 5 ± 1 °C) and at room temperature (T= 22 ± 1 °C). Values represent the mean ± standard deviation (n = 2, †n = 24).

Storage Time (days)	0 day	7 days	14 days	21 days
Weight loss (%, by weight)				
T= 5 ± 1 °C	-	6.05 ± 0.50^{aA}	10.67 ± 0.45^{bB}	17.05 ± 0.72^{cB}
T= 22 ± 1 °C		9.06 ± 1.42^{aA}	16.72 ± 1.33^{bA}	28.55 ± 1.03^{cA}
pH				
T= 5 ± 1 °C	3.94 ± 0.01^{a}	3.77 ± 0.01^{cB}	3.87 ± 0.01^{bB}	3.57 ± 0.02^{dB}
T= 22 ± 1 °C	3.94 ± 0.01^{b}	4.12 ± 0.01^{aA}	3.93 ± 0.01^{bA}	3.87 ± 0.01^{cA}
Total acidity (g/L tartaric acid)				
T= 5 ± 1 °C	3.49 ± 0.16^{bc}	4.20 ± 0.11^{aA}	4.05 ± 0.11^{aA}	4.20 ± 0.11^{aA}
T= 22 ± 1 °C	3.49 ± 0.16^{bc}	3.23 ± 0.11^{cB}	4.13 ± 0.01^{aA}	3.86 ± 0.16^{abA}
Total soluble solids (°Brix)				
T= 5 ± 1 °C	16.9 ± 0.1^{b}	17.1 ± 0.5^{bA}	19.3 ± 0.1^{aA}	18.4 ± 0.1^{aB}
T= 22 ± 1 °C	16.9 ± 0.1^{d}	18.1 ± 0.4^{cA}	19.1 ± 0.1^{bA}	21.5 ± 0.1^{aA}
Color[1]				
L*				
T= 5 ± 1 °C	24.68 ± 2.71^{a}	24.17 ± 1.39^{aB}	24.52 ± 1.46^{aB}	24.18 ± 1.99^{aA}
T= 22 ± 1 °C	24.68 ± 2.71^{a}	24.87 ± 1.13^{aA}	24.72 ± 1.59^{aA}	24.37 ± 1.38^{aA}
a*				
T= 5 ± 1 °C	7.68 ± 2.09^{a}	7.25 ± 1.27^{aA}	6.03 ± 1.57^{bA}	6.03 ± 1.17^{bA}
T= 22 ± 1 °C	7.68 ± 2.09^{a}	6.11 ± 0.80^{bB}	6.08 ± 1.02^{bA}	6.10 ± 0.99^{bA}
b*				
T= 5 ± 1 °C	1.69 ± 0.98^{a}	0.82 ± 0.43^{bA}	0.87 ± 0.69^{bA}	1.06 ± 0.57^{bA}
T= 22 ± 1 °C	1.69 ± 0.98^{a}	0.54 ± 0.38^{bB}	0.75 ± 0.38^{bA}	0.82 ± 0.53^{bA}

The grapes were received in the laboratory, and sampling was conducted at pre-established intervals from day zero up to 21 days. † Replicates collected from 8 grape berries analyzed in 3 different positions. Different lowercase letters in the same row indicate significant differences between samples at all storage times as determined by the Tukey test (5%). Different uppercase letters in the same column indicate significant differences between refrigerated and room temperature samples at each storage time as determined by the *t*-test (5%).

After 21 days of storage, room temperature grapes exhibited a higher weight loss (28.55%) compared to the refrigerated grapes (17.05%) ($p < 0.05$). This aligns with Godana et al. (2022) [6] findings of lower weight loss in fruits stored at 4 °C compared to 20 °C in plastic boxes. Weight loss occurs due to transpiration and metabolic processes like respiration. Lower temperatures reduce metabolism, resulting in lower weight loss [11]. Water loss affects appearance quality, causing wilting, wrinkling, and loss of gloss, reducing market value and increasing susceptibility to fungal decomposition [16]. This behavior can be confirmed in Figure 1, where it can be observed that refrigerated storage better preserved the visual appearance of grape berries after 21 days.

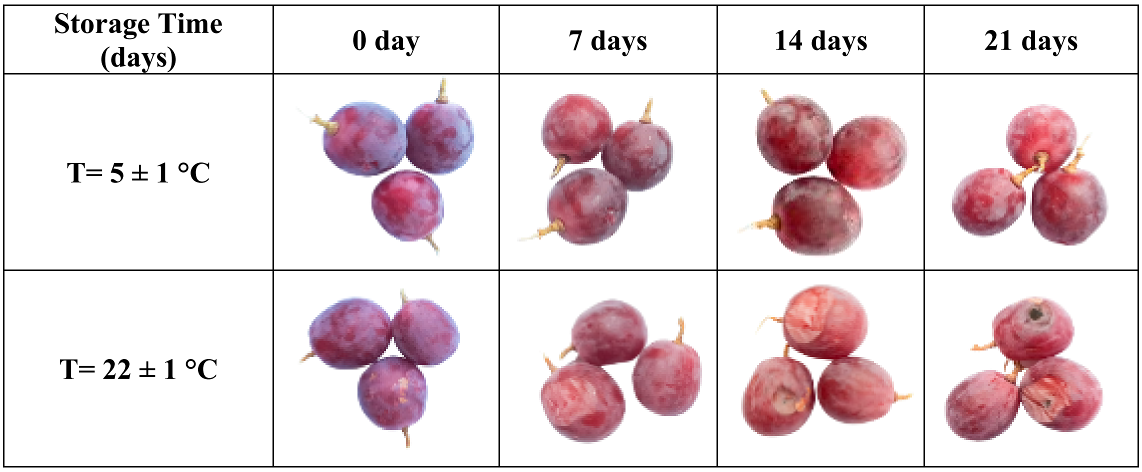

Figure 1: Visual appearance photos of 'Red Globe' table grape berries during storage under refrigeration temperature (T= 5 ± 1 °C) and at room temperature (T= 22 ± 1 °C). The grapes were received in the laboratory, and sampling was conducted at pre-established intervals from day zero up to 21 days.

Over the storage period, pH, total acidity, and colorimetric parameters showed little variation for both storage methods. However, after 21 days, both storage conditions exhibited a significant reduction in pH compared to the initial measurement ($p < 0.05$). Room temperature samples had pH ranging from 3.87 to 4.12, while refrigerated samples ranged from 3.57 to 3.77. The higher pH in room temperature samples may indicate increased consumption of organic acids by the fruit. Variations in total acidity and pH during storage may be attributed to berry dehydration, decreased respiratory rate, and organic acids accumulation [4]. These results may be also due to organic acids and soluble solids transformations during storage, as observed by Konuk Takma and Korel (2017) [13].

Total soluble solids increased over time for both storage conditions. Room temperature samples exhibited greater variation after 21 days (from 16.9 to 21.5 °Brix) compared to refrigerated samples (from 16.9 to 18.4 °Brix). Higher weight loss in room temperature samples could lead to higher sugar concentration and increased total soluble solids, consistent with Zhang et al. (2014) [17] findings. Storage temperature is one of the main factors influencing the increase in soluble solids. In corroboration, Leng et al. (2022) [18] evaluated the effect of postharvest treatments with 1-methylcyclopropene, calcium chloride (1%), ethanol (16%), and the combination of these treatments on the physicochemical quality and decay incidence in table grapes stored at 5 °C and 0 °C. They observed that at 0 °C, the increase in soluble solids content was lower in untreated grape samples compared to both the treated grapes and the control grapes stored at 5 °C.

Color analysis showed no significant differences between treatments for luminosity (L*), a*, and b* parameters within the 21 days of storage ($p \geq 0.05$). Similar results were found in studies on Isabella cultivar table grapes by Guerra et al. (2016) [19]. Babalık et al. (2020) [16] reported that 'Red Globe' table grapes stored for 120 days at 1 °C and 90 % relative humidity exhibited higher L* values (more brightness) for samples treated with carvacrol essential oil compared to the control sample. The a* and b* values varied during storage, but after 120 days, there was no difference between the treatments.

Color is crucial for product acceptability, as it enhances attractiveness and is associated with higher food quality [16].

3.2 Microbiological analyses

Table 2 presents the microbiological counts obtained from the samples.

Table 2: Microbiological count of 'Red Globe' table grapes stored under refrigeration temperature (T= 5 ± 1 °C) and at room temperature (T= 22 ± 1 °C).

Storage Time (days)	**0 day**	**7 days**	**14 days**	**21 days**
Mesophiles (CFU/mL)				
T= 5 ± 1 °C	2.8×10^3	2.9×10^1	3.7×10^3	4.0×10^3
T= 22 ± 1 °C	2.8×10^3	4.7×10^1	n.d.	n.d.
Molds (CFU/mL)				
T= 5 ± 1 °C	$<1 \times 10^0$	$<1 \times 10^0$	$<1 \times 10^0$	$<1 \times 10^0$
T= 22 ± 1 °C	$<1 \times 10^0$	1.0×10^4	n.d.	n.d.
Yeasts (CFU/mL)				
T= 5 ± 1 °C	$<1 \times 10^0$	$<1 \times 10^0$	$<1 \times 10^0$	$<1 \times 10^0$
T= 22 ± 1 °C	$<1 \times 10^0$	$<1 \times 10^0$	n.d.	n.d.

The grapes were received in the laboratory, and sampling was conducted at pre-established intervals from day zero up to 21 days. n.d.: not determined.

According to Portuguese regulations, satisfactory quality ready-to-eat fruits should have a mesophilic count below 10^6 CFU/mL, mold count below 5×10^2 CFU/mL, and yeast count below 10^5 CFU/mL [15]. The refrigerated samples maintained satisfactory parameters for mesophilic bacteria, molds, and yeasts throughout storage. However, the room temperature samples showed a high mold count (1.0×10^4 CFU/mL) after 7 days, exceeding the acceptable limit. Similar findings were reported by Palharini et al. (2015) [20] who observed increased rot incidence in blackberries at higher temperatures, with lower microbial growth at lower temperatures.

Microscopic examination of the isolated mold from the samples revealed conidia formation and conidiophores (Figure 2A), as well as mycelium with branched and septate hyphae, exhibiting a brown color and fruiting structure characteristic of *Botrytis* sp. (Figure 2B), possibly *Botrytis cinerea*. *Botrytis cinerea* is the primary biological cause of post-harvest issues in this fruit, responsible for the formation of gray mold. Fungal spores are typically present on the fruit surface, and damaged fruits, especially those handled improperly, provide a favorable environment for their germination [21].

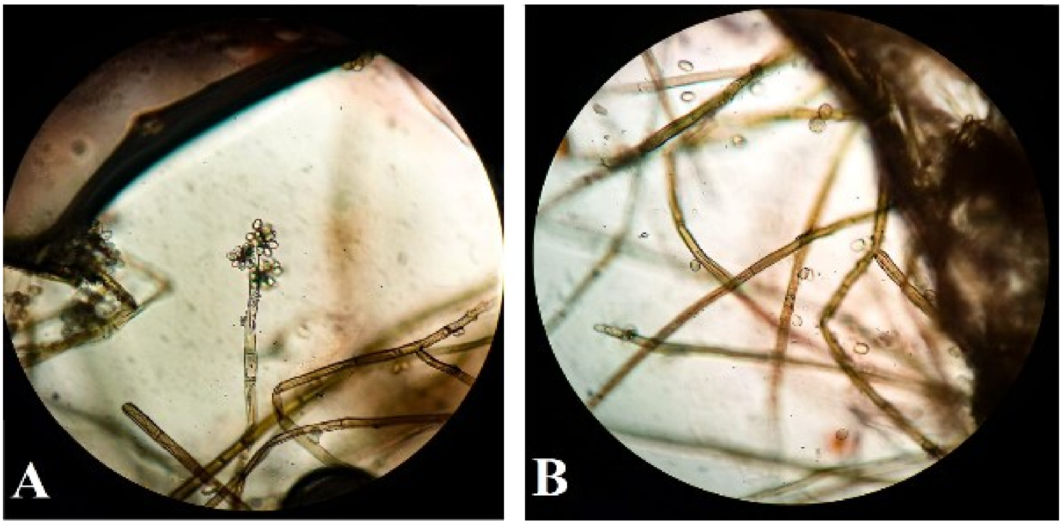

Figure 2: Image obtained with an optical microscope. (A) 400x magnification of the fruiting structure of the mold. (B) 400x magnification of the structure of septate hyphae and conidia characteristic of Botrytis *sp.*

After 14 days, the room temperature sample exhibited advanced deterioration with predominant growth of greenish fungal colonies, and further microbiological counts were not conducted on these samples. Microscope observation of the mold revealed a fruiting structure characteristic of *Penicillium* sp. (Figures 3A and 3B).

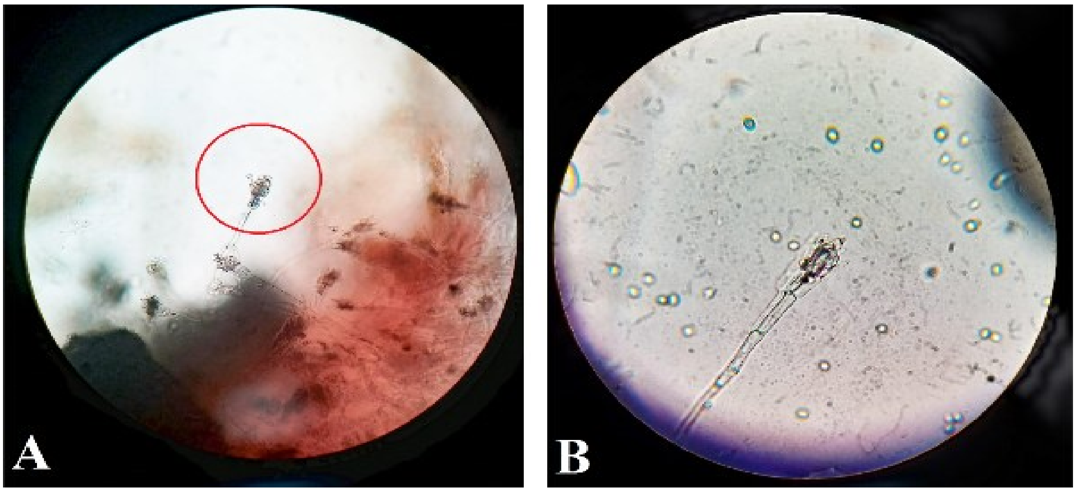

Figure 3: Fruitification structure characteristic of Penicillium *spp. Images obtained under an optical microscope. (A) 400x magnification, where it is possible to observe the fruitification structure. (B) 1000x magnification, where it is possible to visualize the fruitification structure, with septate hyphae and conidia.*

Penicillium sp., similar to *Botrytis* sp., is a fungus known for causing post-harvest damage to subtropical fruits like grapes. It has the ability to produce mycotoxins such as patulin, ochratoxin, citrinin, and others, which can pose health risks to consumers. These mycotoxins have been associated with various adverse effects, inducing plasma membrane rupture, inhibition of protein synthesis, disruption of amino acid synthesis, inhibition of DNA synthesis, and other detrimental effects [22].

3.3 Sensory analysis

Table 3 displays the results of the sensory evaluation of 'Red Globe' table grapes stored under refrigeration. Sensory tests were not conducted throughout the entire storage duration for grapes stored at room temperature, as they did not meet the satisfactory microbiological criteria for consumption after 7 days of storage in the laboratory.

Table 3: Sensory scores of 'Red Globe' table grapes stored under refrigeration (T= 5 ± 1 °C)† (mean ± standard deviation, n = 9)‡.

Storage time (days)	0 day	7 days	14 days	21 days
Overall	7.33 ± 1.00^{a}	7.11 ± 1.62^{a}	4.56 ± 2.13^{b}	7.00 ± 1.32^{a}
Color	7.89 ± 0.93^{a}	7.11 ± 1.27^{ab}	6.22 ± 0.97^{b}	7.00 ± 1.41^{ab}
Odor	5.56 ± 1.51^{a}	6.00 ± 1.32^{a}	5.67 ± 0.87^{a}	5.44 ± 1.24^{a}
Texture	7.78 ± 0.83^{a}	7.00 ± 1.41^{a}	7.22 ± 0.97^{a}	6.11 ± 1.83^{a}
Sweetness	6.11 ± 2.09^{a}	6.56 ± 1.42^{a}	7.22 ± 0.83^{a}	7.00 ± 1.12^{a}
Acidity	6.44 ± 1.51^{a}	7.00 ± 1.32^{a}	7.22 ± 0.83^{a}	6.67 ± 1.41^{a}
Overall quality	7.11 ± 1.36^{a}	6.67 ± 0.90^{a}	6.67 ± 0.87^{a}	6.56 ± 1.33^{a}

The grapes were received in the laboratory, and sampling was conducted at pre-established intervals from day zero up to 21 days. † Samples stored at 22 ± 1 °C were not analyzed due to the microbiological analyses results. ‡ Different lowercase letters in the same row indicate significant differences between samples. Equal letters do not differ from each other by Tukey's test (5%).

The refrigerated grapes were moderately liked (score 7 point) for overall appearance during storage after 21 days (Table 3), confirming visual results previously described on Figure 1.

No significant differences were observed in the attributes of odor, texture, sweetness, acidity, and overall quality for grapes stored for 21 days under refrigeration ($p \geq 0.05$). Furthermore, the scores for most attributes were ≥ 6 ("liked") after 21 days of storage, except for odor which received scores ≥ 5 and < 6 ("neither liked nor disliked"). Similarly, the preservation of grape appearance under refrigeration was consistent with the findings of Mattiuz et al. (2009) [11]. In the present study, the overall appearance of refrigerated grapes showed a decrease in acceptance after 14 days of storage, followed by an increase up to 21 days ($p < 0.05$), likely due to color changes occurring during storage.

Storage temperature is the most critical environmental factor influencing the rate of deterioration and shelf life of fruits and vegetables. Effective cold chain management during export and trade is essential to preserve the sensory quality and shelf life of exported grapes [12]. Thus, the findings presented reinforce that temperature control should be extended to post-purchase storage in order to ensure fruit quality and prolong shelf life.

4. CONCLUSION

This study demonstrated the substantial impact of storing grape berries under refrigeration on their physicochemical, physical, microbiological, and sensory parameters, thereby significantly preserving their quality compared to samples stored at room temperature throughout a 21-day period. The refrigerated samples consistently met the satisfactory microbiological criteria for consumption and exhibited favorable acceptability ratings throughout the entire storage duration. These compelling findings highlight the paramount importance of maintaining low temperatures throughout the entire production chain, including the stages of export, distribution, commercialization, and domestic storage of table grapes, in order to ensure their unparalleled quality over an extended period and with minimal losses.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

1. Sabra A, Netticadan T, Wijekoon C. Grape bioactive molecules, and the potential health benefits in reducing the risk of heart diseases. Food Chem X. 2021;12:100149. doi: 10.1016/j.fochx.2021.100149
2. Río Segade S, Giacosa S, Torchio F, de Palma L, Novello V, Gerbi V, et al. Impact of different advanced ripening stages on berry texture properties of "Red Globe" and "Crimson Seedless" table grape cultivars (*Vitis vinifera* L.). Sci Hortic. 2013;160:313-9. doi: 10.1016/j.scienta.2013.06.017
3. Alenazi MM, Shafiq M, Alobeed RS, Alsdon AA, Abbasi NA, Ali I, et al. Application of abscisic acid at Veraison improves red pigmentation and accumulation of dietary antioxidants in red table grapes Cv. Red Globe at harvest. Sci Hortic. 2019;257:108672. doi: 10.1016/j.scienta.2019.108672
4. Aubert C, Chalot G. Chemical composition, bioactive compounds, and volatiles of six table grape varieties (*Vitis Vinifera* L.). Food Chem. 2018;240:524-3. doi: 10.1016/j.foodchem.2017.07.152
5. Basile T, Alba V, Gentilesco G, Savino M, Tarricone L. Anthocyanins pattern variation in relation to thinning and girdling in commercial Sugrathirteen® table grape. Sci Hortic. 2018;227:202-6. doi: 10.1016/j.scienta.2017.09.045
6. Godana EA, Yang Q, Liu J, Li J, Zhang X, Zhao L, et al. Consumer evaluation of sensory properties of table grapes treated with *yeast Pichia anomala* induced by chitosan. Biol Control. 2022;170:104939. doi: 10.1016/j.biocontrol.2022.104939
7. Zhang Z, Xu J, Chen Y, Wei J, Wu B. Nitric oxide treatment maintains postharvest quality of table grapes by mitigation of oxidative damage. Postharvest Biol Technol. 2019;152:9-18. doi: 10.1016/J.POSTHARVBIO.2019.01.015
8. Admane N, Genovese F, Altieri G, Tauriello A, Trani A, Gambacorta G, et al. Effect of ozone or carbon dioxide pre-treatment during long-term storage of organic table grapes with modified atmosphere packaging. LWT. 2018;98:170-8. doi: 10.1016/J.LWT.2018.08.041
9. Ziegler M, Rüegg S, Stephan R, Guldimann C. Growth potential of *Listeria monocytogenes* in six different RTE fruit products: Impact of food matrix, storage temperature and shelf life. Ital J Food Saf. 2018;7:142-7. doi: 10.4081/ijfs.2018.7581
10. de Sousa LL, de Andrade SCA, Athayde AJAA, de Oliveira CEV, de Sales CV, Madruga MS, et al. Efficacy of *Origanum vulgare* L. and *Rosmarinus officinalis* L. essential oils in combination to control postharvest pathogenic Aspergilli and autochthonous mycoflora in *Vitis labrusca* L. (table grapes). Int J Food Microbiol. 2013;165:312-8. doi: 10.1016/j.ijfoodmicro.2013.06.0011
11. Mattiuz B-H, Almeida Miguel AC, Galati VC, Nachtigal JC. Efeito da temperatura no armazenamento de uvas apirênicas minimamente processadas. Rev Bras Frutic. 2009 Mar;31(1):44-52. doi: 10.1590/S0100-29452009000100008
12. Goedhals-Gerber LL, van Dyk E, Getor RY, Louw B, Mishra N. Identifying container hotspots for table grape exports from South Africa to the UK: A case study. Transp Res Interdiscip Perspect. 2024;24:101054. doi: 10.1016/j.trip.2024.101054
13. Konuk Takma D, Korel F. Impact of preharvest and postharvest alginate treatments enriched with vanillin on postharvest decay, biochemical properties, quality and sensory attributes of table grapes. Food Chem. 2017;221:187-95. doi: 10.1016/j.foodchem.2016.09.195
14. Liguori G, Sortino G, Gullo G, Inglese P, Chrysargyris A, Pearson S. Effects of modified atmosphere packaging and chitosan treatment on quality and sensorial parameters of minimally processed cv. "Italia" table grapes. Agronomy. 2021;11(2):328. doi: 10.3390/agronomy11020328
15. Saraiva M, Correia CB, Cunha IC, Maia C, Bonito CC, Furtado R, et al. Interpretação de resultados de ensaios microbiológicos em alimentos prontos para consumo e em superfícies do ambiente de preparação e distribuição alimentar: valores-guia. Lisboa (PT): Lisbon Instituto Nacional de Saúde Doutor Ricardo Jorge; 2019. Available from: http://repositorio.insa.pt//handle/10400.18/5610.
16. Babalık Z, Onursal CE, Erbaş D, Koyuncu MA. Use of carvacrol helps maintain postharvest quality of Red Globe table grape. J Anim Plant Sci. 2020;30:655-62. doi: 10.36899/JAPS.2020.3.0078
17. Zhang J, Li D, Xu W, Fu Y. Preservation of Kyoho grapes stored in active, slow-releasing pasteurizing packaging at room temperature. LWT. 2014;56:440-4. doi: 10.1016/j.lwt.2013.11.017
18. Leng F, Wang C, Sun L, Li P, Cao J, Wang Y, et al. Effects of different treatments on physicochemical characteristics of 'Kyoho' grapes during storage at low temperature. Horticulturae. 2022;8(2):94. doi: 10.3390/horticulturae8020094

19. Guerra ICD, de Oliveira PDL, Santos MMF, Lúcio ASSC, Tavares JF, Barbosa-Filho JM, et al. The effects of composite coatings containing chitosan and *Mentha* (*piperita* L. or x *villosa* Huds) essential oil on postharvest mold occurrence and quality of table grape cv. Isabella. Innov Food Sci Emerg Technol. 2016;34:112-21. doi: 10.1016/j.ifset.2016.01.008
20. Palharini MCA, Fischer IH, Vegian MRC, Fileti MS, Montes SMNM. Efeito da temperatura de armazenamento na conservação pós-colheita de amora-preta. Pesqui Agropecu Trop. 2015;45:413-9. doi: 10.1590/1983-40632015v4537752
21. de Simone N, Pace B, Grieco F, Chimienti M, Tyibilika V, Santoro V, et al. *Botrytis cinerea* and table grapes: A review of the main physical, chemical, and bio-based control treatments in post-harvest. Foods. 2020 Aug;9(9):1138. doi: 10.3390/foods9091138
22. Dwiastuti ME, Soesanto L, Aji TG, Devy NF, Hardiyanto. Biological control strategy for postharvest diseases of citrus, apples, grapes and strawberries fruits and application in Indonesia. Egypt J Biol Pest Control. 2021;31:141. doi: 10.1186/s41938-021-00488-1