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Duration and Temperature Influence on The Stored Grapes

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تأثير الزمن ودرجة الحرارة على العنب المُخزَّن

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Abstract
Stored grapes fruit quality are affected by conditions such as time and temperature. The improper conditions can influence our reserve food quality. Some grape clusters are collected from a farm which is located in Tripoli. These clusters were stored for fifteen days at different storage temperatures such as a refrigerator that is set at 5°C, room with air conditioner which is set at 18°C and ambient condition where the temperature is about 38°C. The purpose of this research in to assess the impact of temperature and time on pH and titratable acidity (TA). The obtained information was analyzed by IBM SPSS software version 25 statistics and expressed as mean±standard deviation using Two-way ANOVA. The procured results revealed that pH values gradually increase in whole storage temperatures for entire duration. For instance, the pH values between 7th and 8th day changed from 3.42 to 3.46 at 5°C, 3.38 to 3.43 at 5°C and 3.26 to 3.31 at 38°C. Similarly, the titratable acidity (TA) values showed a gradually increase for whole stored period as well. For instance, the TA values between 3th and 4th day changed from 0.61 to 0.62 at 5°C, 0.63 to 0.65 at 5°C and 0.64 to 0.66 at 38°C. additionally, the Duncan's multiple range test analysis has revealed that is a significant difference between the entire grape clusters samples at different temperatures and time (P-value < 0.05). In conclusion, the pH and titratable acidity (TA) of stored postharvest grapes have been substantially influenced by different temperature and duration.

Keywords: Grapes, duration storage, temperature, pH, TA.

الملخص
تتأثر جودة ثمار العنب المخزنة بظروف مثل الوقت ودرجة الحرارة. يمكن أن تؤثر الظروف غير المناسبة على جودة طعامنا الاحتياطي. تم جمع بعض عناقيد العنب من مزرعة تقع في طرابلس. تم تخزين هذه العناقيد لمدة خمسة عشر يومًا في درجات حرارة تخزين مختلفة مثل الثلاجة التي تم ضبطها على 5 درجات مئوية، وغرفة مع مكيف هواء تم ضبطها على 18 درجة مئوية وظروف محيطة حيث تكون درجة الحرارة حوالي 38 درجة مئوية. الغرض من هذا البحث هو تقييم تأثير درجة الحرارة والوقت على الرقم الهيدروجيني والحموضة القابلة للمعايرة (TA). تم تحليل المعلومات التي تم الحصول عليها بواسطة إحصاءات برنامج IBM SPSS الإصدار 25 وتم التعبير عنها على أنها متوسط ± الانحراف المعياري باستخدام تحليل التباين ثنائي الاتجاه. كشفت النتائج التي تم الحصول عليها أن قيم الرقم الهيدروجيني تزداد تدريجيًا في درجات حرارة التخزين الكاملة طوال المدة. على سبيل المثال، تغيرت قيم الرقم الهيدروجيني

بين اليوم السابع والثامن من 3.42 إلى 3.46 عند 5 درجات مئوية، ومن 3.38 إلى 3.43 عند 5 درجات مئوية، ومن 3.26 إلى 3.31 عند 38 درجة مئوية. وبالمثل، أظهرت قيم الحموضة القابلة للمعايرة (TA) زيادة تدريجية لكامل فترة التخزين أيضًا. على سبيل المثال، تغيرت قيم TA بين اليوم الثالث والرابع من 0.61 إلى 0.62 عند 5 درجات مئوية، ومن 0.63 إلى 0.65 عند 5 درجات مئوية، ومن 0.64 إلى 0.66 عند 38 درجة مئوية. بالإضافة إلى ذلك، كشف تحليل اختبار دنكان متعدد النطاقات عن وجود فرق كبير بين عينات عناقيد العنب بأكملها عند درجات حرارة وأوقات مختلفة ($P < 0.05$). وفي الختام، تأثر الرقم الهيدروجيني والحموضة القابلة للمعايرة (TA) لعنب ما بعد الحصاد المخزن بشكل كبير بدرجات الحرارة والمدة المختلفة.

الكلمات المفتاحية: الحرارة، الرقم الهيدروجيني، العنب، العيارية الحمضية، مدة التخزين.

1. Introduction

The one of the most essential fruits of horticultural are grapes (*Vitis vinifera L.*) which are widely demanded crops (Parker, et. Al., 2015). In production terms, the grapes are considered a very valuable fruit as compared to other various crops which reflect a positive economically impact on the world states (Parker, *et. al.,* 2015; Vlassi, *et. al.* 2018). Consequently, the premium requirements are substantially necessary for optimal postharvest storage conditions for grapes fruit. Several researchers in the literature review explained the current and past studies knowledge about the influences of storage period and temperature on the pH and titratable acidity properties of grapes (*Vitis vinifera L.)* crops. Although our progressively improving knowledge in the practice of management to temper grapevine development and growth, viticulture can be a section very vulnerable to temperature and weather climate as a result of these characteristics niche for premium grapes (Jones 2006; Barnuud, et. al., 2014). Grape acidity is drastically considered one of the statuses attributes of grape quality and circumstance of this parameter that play a significant role for grape quality (Barnuud, et. al., 2014). Therefore, the storage of grapes in the different storage conditions facilities such as artificial cooling may have an effectiveness on the pH value (Nabiyev, *et. al*., 2024). The store of fresh grape into refrigerator facilities can be an industrial effectiveness technique associated with predefined optimum system (Nabiyev, *et. al.,* 2024; Orucov, V. M., 2014). The fruit organoleptic high quality mainly relies on the organic acid, sugar contents and characteristic of aroma. Through maturation of fruits, these content and characteristic had been extensively researched (Tucker 1993; Diakou, 1997). The most common organic acids in the fruit such as grape berries are tartaric and malic through growth, the malic acid is considered the main respiration acid through ripping (Lavee and Nir 1986; Raisins, *et., al.,* 2018; Diakou, 1997).
There are approximately more than 90% of malic and tartaric acids in the constituents of the grape must. The tartaric content is the predominant acid in the mature grapes of *Vitis vinifera* which are ranged from 5 to 10 g/L (Watrelot and Moroney, 2020). The grape juice palatability is influenced by low and high acid concentration (Ruffner 1982; Diakou, 1997). The malic acid concentration reduction cause to reduce the acidity through ripping (Ruffner and Hawker 1977; Diakou, 1997). The common acids in the grape fruit are the tartaric and malic content. The acceptable of produced fresh grape juice is attributed to the acids organoleptically contribution. Additionally, these acids contribute to postponement spoilage of microbial as well as color stabilization. Therefore, the acids play the most important role in the grape fruit quality. The previous study demonstrated that tartrate and malate acids concentration are markedly predominant among about seventy-eight vinifera juice of grape varieties (Kliewer *et. al.,* 1967), however, the acids are reduced during ripping. Moreover, the other analysis such berry grapes of Thompson Seedless is shown a reduction of malate and tartrate acids was occurred

throughout ripping period (Kliewer,1966). Similarly, in the South Africa, the analyzing of some cultivated grape demonstrated that the concentration of the common acids such as malate and tartrate were decreased (Du Plessis, 1968). Kliewer observed the acid reduction rate rely on the temperature and cultivar (Kliewer, 1971). The temperature can influence on the grape maturity and its development (Parker, *et. al.,* 2015).

2. Ethylene production from fruits

Several species of plants produce ethylene gas (C_2H_4). This gas is formed as a result of fruits metabolism. The fruits generate ethylene and disperse it around in the air, so it controls development of fruits in the storage. In addition, the ethylene production rate may become high during fruit ripping as a result of the high temperature effect on the fruits (Müller et. al., 2000; Irtwange, 2006). On the other hand, the low storage temperature conditions and long term of storage might have a negative affect on the ethylene production rate (Irtwange, 2006; Ali, 2011).

3. Fruits respiration

The fruit respiration generates the carbon dioxide due to used oxygen at the atmosphere condition. The glucose metabolic oxidation chemical equation is expressed as following (Irtwange, 2006):

$$C_6H_{12}O_6 + 6O_2 \dashrightarrow 6CO_2 + 6H_2O + heat \quad \ldots\ldots(1)$$

Therefore, it surely can be figure out from the chemical recreation equation, the wasted fruit reserves content such as glucose sugar can be occurred due to heat transfer (Irtwange, 2006).

4. Methodology

Grapes (*Vitis vinifera L.)* fresh clusters samples without microbial or physical damage were collected from domestic orchards in Tripoli, Libya. The grapes bunch samples harvested in July, 2024. In addition, sodium chloride (NaCl) and deionized distilled water were used for titration. The clusters were harvested with skin green, and purple color, so in this time stage, the grapes samples continue to normally ordinary after harvest. All clusters samples were in good quality.

4.1 Storage conditions

The grapes samples have been harvested and directly stored at different temperatures that the most crucial parameter that effects the fruit. The samples were successfully set in a proper condition for prolonged storage period. The fruit has been kept in a dark environment. The grape samples were never freezing and all kept away of pests and animals such as insects and mice. The storage conditions have been divided into three parts. Firstly, a separated room includes an air conditioner that is set at 18±2°C. Secondly, an opened room system to the air at atmospheric conditions such temperature is about 38±3°C. Thirdly, a storage was into a refrigerator compartment where the temperature is about 5±1°C. The storage period was fifteen days where the analysis has been taken every day.
The fruits release gas of ethylene that can accelerate the ripening system (Conde *et. al.,* 2007; Janick and Moore, 1996; Ashworth, 2002)

4.2 pH and titratable acidity (TA) Measurement

There are about fifty cm^3 volume of grape juice collected from different storage temperature of (5 ±1, 18±2, 38±3) °C at different time storage period start from first day to the fifteenth day. Entire the grape sample have been kept in the room temperature prior to taking measurement of pH and titratable acidity (TA). The pH parameter was measured by a pH meter. For each grape sample, there are sis grams of grape juice have been weighted in a 100 cm^3 beaker. Whole the samples have been titrated by utilizing burette of 0.1 N NaOH to the last point of 8.2 that measured by pH meter and the volume of NaOH has been written down in cm^3 (Awoyale et al., 2015). The titratable acidity can be estimated as follows:

$$\%\ Acid = \frac{[ml\ NaOH\ used]\ .\ [0.1\ N\ NaOH].\ [ml\ equivalent\ factor](100)}{grams\ of\ sample} \quad \ldots\ldots\ldots\ldots(2)$$

4.3 Statistical Analysis

The analysis of obtained grape samples data has been used by IBM SPSS software version 25 statistics. The Duncan's multiple range as well as Variance analysis (Two-way ANOVA) have been used to compare any significant differences between grape juice samples. Values have been expressed as means ± standard deviations. Differences were substantially significant at P-value < 0.05. All the analyses were accomplished in triplicates.

5. Results and discussion

Whole influence of storage time and temperature on the fresh grapes clusters samples postharvest have been demonstrated after the statistical analysis of SPSS runs.

5.1 pH

The results procured from ANOVA analysis have demonstrated that the dependent variable of pH values of stored grape clusters samples substantially illustrated significant differences and influenced by days and temperature ($P<0.05$) in all storage conditions as shown in Table 1. Moreover, the Duncan's multiple range test demonstrated that the mean values of dependent pH of grape sample clusters have been significantly changed compared to each other at different storage temperatures as depicted in Table 2. However, the pH of whole stored grape samples prolonged storage period has not revealed a significant change between sample at from 2^{nd} to the 5^{th} day. For example, the pH are 3.36 at 5°C, 3.33 at 18°C and 3.31 at 38°C at 4^{th} day, the pH are 3.37 at 5°C, 3.32 at 18°C and 3.22 at 38°C at 5^{th} day which reflects no substantially time effect on the sample during this period as displayed in Table 3.

The pH of stored grape clusters under three temperatures of storage (5 ±1, 18±1, 38±3) °C and durations of fifteen days have been illustrated in Figure 1. From Figure 1, it is clear that pH gradually increases in all storage conditions prolonged storage period. In addition, the pH value slow gradually increases into ambient condition storage compared to those samples into room with air conditions. On the other hand, the pH values of grape clusters more gradually increase into room with air conditioner that is set at 18 °C compared to the samples which are into the refrigerator with temperature of 5 °C. Generally, all pH values of samples between 3 to 3.4 at all conditions are gradually increase as a result of grape clusters gradually ripen which is attributed to the organic acids such as malic acid inside the grape samples begin to decompose.

In this stage, the sugar begins to accumulate in such large quantities which leads fruit to be rich of flavor (Apure, 2025). Moreover, the pH values in both storage conditions such as 18°C and 38°C increase between 3.4 to 4 which attributed to the tartaric and malic acids continue to substantially decrease during storage periods as a result of minerals such as sodium and potassium to be accumulated. So, the glucose and acidity levels are markedly balanced at this pH stage. Therefore, at this pH stage, the grapes are considered at critical period for eating (Apure, 2025). The stored samples pH has shown a higher increase at cold storage of 5°C prolonged storage periods. In this case, the organic acid in the grapes are used as substrates for the respiration enzymatic reaction (Bico, et al., 2009). The oxygen level into refrigerator might be declined at the fifth day, therefore, this leads the fruit respiration rate level to be reduced which attributes to delay organic acids to be used (Bico, et al., 2009).

Table 1: Dependent Variable: pH

Parameter	df	Mean Square	F	P-value
Temperature	2	1.698	872.820	0.000
Time	14	0.323	165.984	0.000
Temperature * Time	28	0.107	54.961	0.000
Error	90	0.002		
Total	135			

Table 2: pH mean±standard deviation and significant differences.

Temperature	
Duncan's multiple range test	
Dependent Variable: pH	
Temperature	Mean of pH
5.00	3.700±.007a
18.00	3.412±.007b
38.00	3.330±.007c

Table 3: pH mean±standard deviation and significant differences.

Time	
Duncan's multiple range test	
Dependent Variable: pH	
Day	Mean of pH
1	3.227±.015a
2	3.290±.015b
3	3.333±.015b,c
4	3.303±.015b
5	3.327±.015b,c
6	3.353±.015c
7	3.400±.015d
8	3.407±.015d
9	3.457±.015e
10	3.557±.015f
11	3.623±.015g
12	3.667±.015h
13	3.690±.015h
14	3.790±.015i
15	3.790±.015i

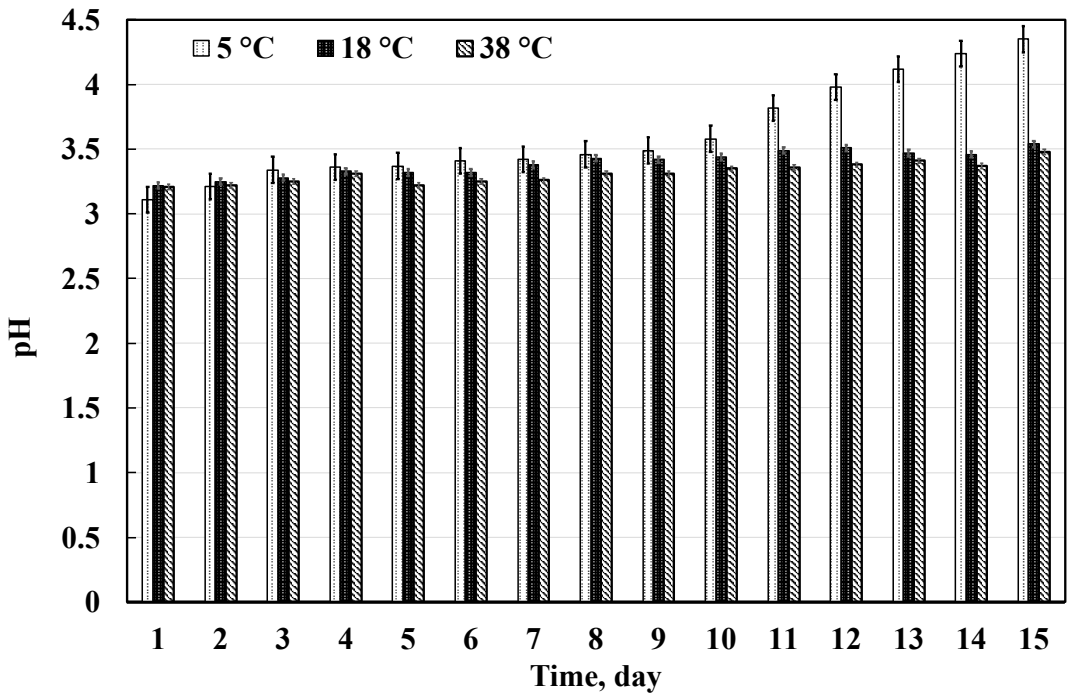

Figure 1: pH of grape clusters for 3 storages.

5.2 Titratable Acidity (TA)

It can be noticed that the grapes samples clusters titratable acidity (TA) gradually increases into whole different storage temperatures storage (5 ±1, 18±1, 38±3)°C which might be as a

result of reduction of moisture content as shown in Figure 2 (Doshi and Adsule, 2006). On the other hand, the increase rate into samples of ambient condition was higher than TA rate of samples that present into room with air conditioner. Similarly, the TA of samples under refrigerator condition exhibits low rate compared to samples TA at temperature of 18°C storage for whole stored period. Additionally, at cold conditions such as 5°C, the grapes nutrients that are used for respiration process are broken down as a result of increase of enzyme activity which lead to decomposition of organic and inorganic substances in grape samples (Nabiyev, *et. al*., 2024).

Besides. The SPSS ANOVA analysis has exhibited that the titratable acidy TA dependent variable has drastically displayed a significant change in entire stored clusters samples at different temperature and duration where P-value <0.05 as depicts in Table 4**.** Furthermore, the Duncan's multiple range test revealed that the mean values of dependent titratable acidity (TA) of stored grape clusters have been markedly changed compared to one another at variation storage temperatures as exhibited in Table 5. On the other hand, from Table 6, the titratable acidity TA throughout whole time into storage of ambient conditions, room with air conditioner and refrigerator did not show a remarkable difference in samples at 3rd and 4th day. In this time, for instance, the TA are 0.61 at 5°C, 0.63 at 18°C and 0.64 at 38°C at the 3rd day, and TA are 0.62 at 5°C, 0.65 at 18°C and 0.66 at 38°C at the 4th day. Similarly, there is not a remarkable change from 5th to 7th day. Therefore, the time did not show any effect on the TA of clusters.

Table 4: Dependent Variable: TA.

Parameter	df	Mean Square	F	P-value
Temperature	2	0.04	49.06	0.000
Time	14	0.07	86.182	0.000
Temperature * Time	28	0.002	2.686	0.000
Error	90	0.001		
Total	135			

Table 5: TA mean±standard deviation and significant differences.

Temperature	
Duncan's multiple range test	
Dependent Variable: TA	
Temperature	Mean of TA
5.00	.678±.004a
18.00	.715±.004b
38.00	.738±.004c

Table 6: TA mean±standard deviation and significant differences.

Time	
Duncan's multiple range test	
Dependent Variable: TA	
Day	Mean of TA
1	.558±.01a
2	.593±.01b
3	.629±.01c
4	.645±.01c,d
5	.660±.01d,e
6	.674±.01e
7	.687±.01e,f
8	.707±.01f,g
9	.724±.01g,h
10	.736±.01h,i
11	.761±.01i,j
12	.777±.01j,k
13	.795±.01k
14	.843±.01L
15	.866±.01L

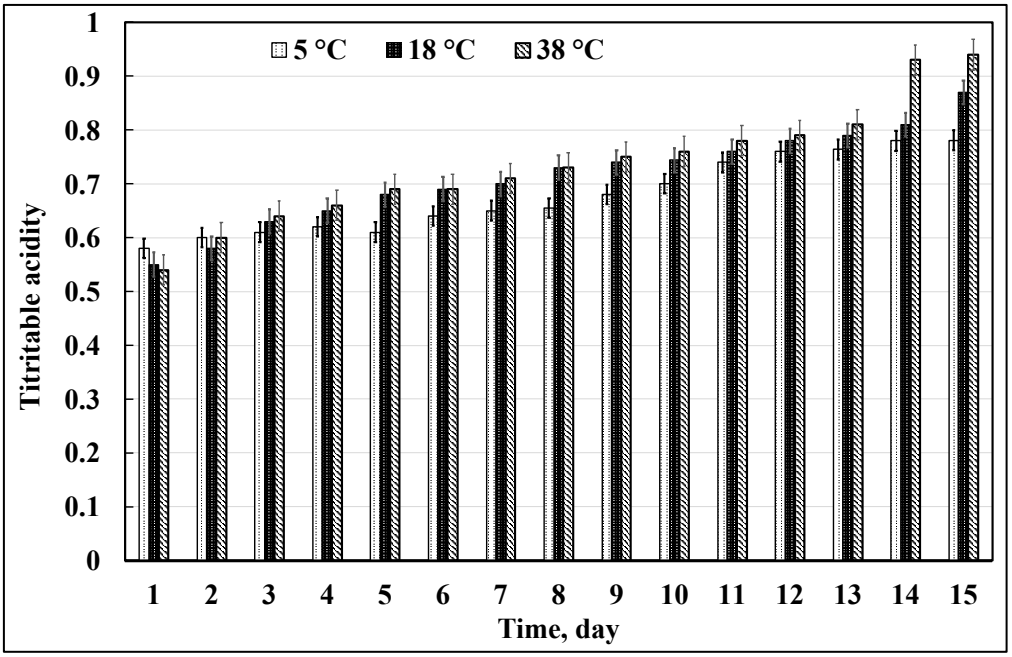

Figure 2: Titratable acidity (TA%) of grape clusters for 3 storages.

6. Conclusion

This experiment work reflects a reliable study about pH and titratable acidy (TA) of stored grapes samples fruit in the Tripoli city. These dependent parameters are drastically affected by temperature and duration of 15 days at variation of storages such as ambient condition, room with air conditions and cold environment of refrigerator. However, in some cases, the

dependent variables of pH and TA never show a significant time effect on the grapes in some days. The storage conditions of 4°C and 10°C are recommended for future experiment work with respect to long term of duration.

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