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Evaluation of Coenzyme Q10 Addition and Storage Temperature on Some Physicochemical and Organoleptic Properties of Grape Juice

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ABSTRACT

Todays, parallel to growing in acceptance of functional products, various additives are used to improve the characteristics of functional food products. The coenzyme Q10 is an essential component for energy conversion and production of adenosine triphosphate (ATP) in the membranes of all body cells and organelles, especially the inner mitochondrial membrane is found. Coenzyme Q10 plays a vital role in cellular energy production. It also increases the body's immune system via its antioxidant activity. The aim of this study was to evaluate the addition of coenzyme Q10 on physicochemical properties of grape fruit juice. The variables were concentrations of coenzyme Q10 (10 or 20 mg in 300 mL) and storage temperature (25°C and 4°C) and the parameters were pH, titrable acidity, brix, viscosity, turbidity and sensory evaluation during three months of storage. By increasing time and temperature, pH was decreased and with increasing concentration of coenzyme Q10, pH was increased. Time and temperature had direct influence on acidity, and the concentration of coenzyme Q10 had the opposite effect on the acidity. With increasing storage time and concentration of coenzyme Q10, Brix, viscosity and turbidity levels were increased and with increasing time and concentration of coenzyme Q10, the Brix, viscosity and turbidity were increased. The addition of coenzyme Q10 in grape juice showed no negative effect on the physicochemical and sensory properties.

Keyword: Coenzyme Q10; Grape juice; Physicochemical properties; Sensory evaluation; Storage temperature.

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1. INTRODUCTION

Coenzyme Q10 is a mediated electron transfer between flavoproteins and cytochromes in mitochondrial respiratory chain and has a cofactor role in three mitochondrial enzymes. Coenzyme Q10 in addition to energy transfer, as an antioxidant, protects the oxidation of membrane phospholipids and mitochondrial membrane protein and low-density lipoprotein particles [1]. The chemical name of Coenzyme Q10 is 2,3-dimethoxy-5-methyl-6-polyisoprene parabenzo-quinone. The letter 'Q' refers to quinone chemical group and the digit '10' indicates the number of isopernil chemical subunits [2]. The chemical structure of coenzyme is shown in Figure 1.

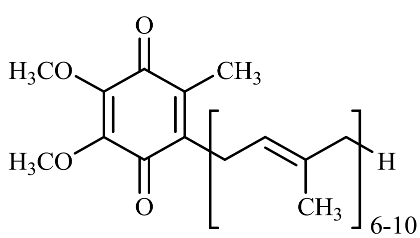

Figure 1: *The chemical structure of coenzyme Q10*

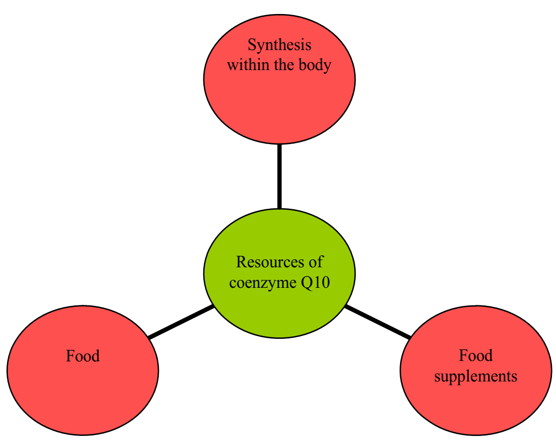

Figure 2: *Resources of coenzyme Q10*

Table 1: *Coenzyme Q10 levels in selected foods*

CoQ10 levels in selected foods	
food	**Coenzyme Q10 concentration [mg/kg]**
Meat	
- heart	113
- liver	39-50
- beef	16-40
- pork	13-45
- chicken	8-25
Fish	
- sardine	5-64
- red flash	43-67
- white flash	11-16
- salmon	4-8
- tuna	5
Oils	
- soybean	54-280
- olive	4-160
- grapeseed	64-73
- sunflower	4-15
Nuts	
- peanuts	27
- walnuts	19
- sesame seeds	18-23
- pistachio nuts	20
- hazelnuts	17
- almond	5-14
Vegetables	
- parsley	8-26
- broccoli	6-9
- cauliflower	2-7
- spinach	up to 10
- rape	6-7
- Chinese cabbage	2-5
Fruit	
- avocado	10
- blackcurrant	3
- strawberry	1
- orange	1-2
- grapefruit	1
- apple	1

Needed resources of coenzyme Q10 in the body can be obtained in three ways, synthesis within the body, food and food supplements, or a combination of these factors (Figure 2) [2]. Due to the complexity of the biosynthesis of this substance, deficiency of coenzyme Q10 is possible [3]. Food can usually provide in average 10 mg of needed coenzyme Q10 in the body, while it have been reported that the sufficient intake for a healthy body is 30 mg per day [4]. Therefore, the obtained results show the need to use coenzyme Q10 as a drug or dietary supplement [5]. The results obtained about stability of coenzyme Q10 in fortified dairy products is consenting so that any changes in the microbial, chemical and physical components of the type has not seen yet [6-8]. Coenzyme Q10 levels in some foods is shown in Table 1 [8].

Research in 2010 showed that use of fruits juice such as grape fruit juice increased the absorption of coenzyme Q10 in the human intestine [9]. Also, use of coenzyme Q10 increased the vitamin content in the liver and serum of rats [10]. According to the survey results, fruit juice can be suitable to be enriched with this invaluable coenzyme. Biochemical and medical studies have shown that grapes have phenolic content and antioxidant properties and can be a good source of nutrition. Grape juice has more than 2 times more antioxidants than oranges, apples, grapefruit and tomatoes [11]. The grape has antioxidant property and actually has the capacity of free-radical absorbance. This property is related to its phenolic content [12]. Grapes help inhibit of heart disease, neurological diseases, viral infections and

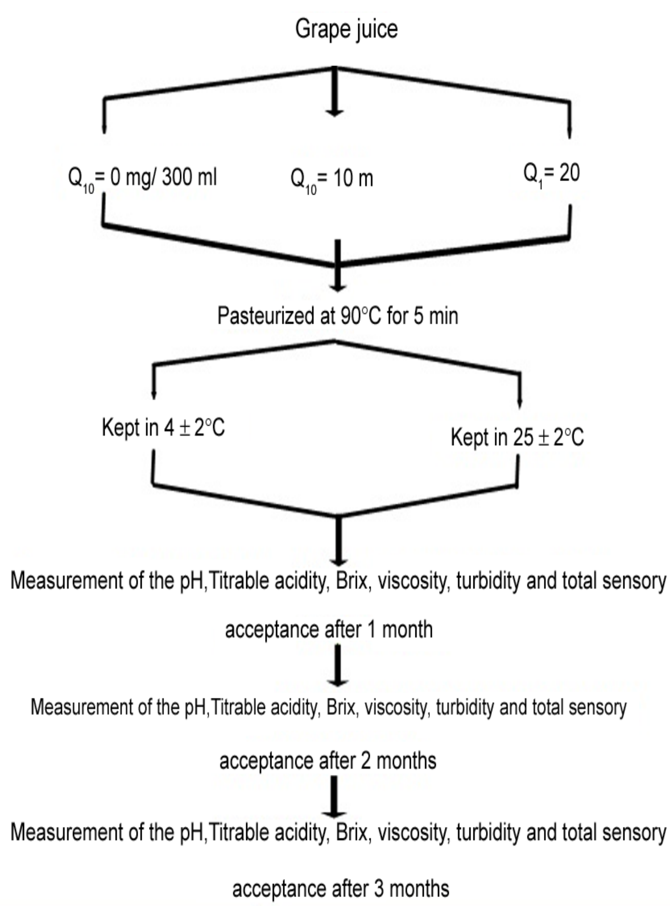

Figure 3: *Flowchart of study*

Alzheimer [13]. Grape juice inhibits platelet and has anti-coagulation of blood property [14]. Grape juice stimulates the production of nitric oxide which is a vasodilator by platelets. This material causes normal blood flow and actually reduces blood pressure in people who are suffering blood pressure [15]. In medical research studies have reported potential benefits of grape juice on the stage of the cancer start [16]. Grape juice is also effective in the prevention and improvement of atherosclerosis [17]. Anthocyanins in the grape juice have significant antioxidant property and play important biological role in mammals. They are directly involved in the protection of DNA, and indirectly can also reduce oxidative stress. Anthocyanins enable detoxifying enzymes such as Glutathione Reductase, Glutathione Geroxidase, Glutathione S-Transferase and Oxidoreductase quinone [18]. Anthocyanins may reduce body weight and prevent fat accumulation and diabetes which is caused by that [19]. The aim of this study was to investigate the effects of adding coenzyme Q10 into grape juice on its some physicochemical properties and sensory attributes.

2. MATERIALS AND METHODS

2.1. Sample preparation

Coenzyme Q10 (Sensus, Netherlands) added into 300 mL grape juice (Takdaneh, Iran) at three levels: 0, 10 and 20 mg. The samples filled into sterile bottles and were pasteurized at 90°C for 5 min. Grape juice packs were kept in refrigerated temperature at two temperatures (4 or 25 ± 2°C) for 3 months, per one-month intervals (Figure 3).

2.2. Physicochemical analysis and sensory evaluation

Measurement of the pH were done with a pH meter (Crison, Spain), Brix with a refractometer (Optech, Germany), viscosity with a viscometers (Brookfield, America), and turbidity with a spectrophotometer (Cromtech, Taiwan). Titrable acidity was measured via titration method. Sensory characteristics of the samples were examined using a 5-point Hedonic test. The total sensory acceptance was calculated and compared among treatments as final sensory parameter.

Statistical analysis Experiments were performed in triplicate and significant differences between means were analyzed using two-way ANOVA test from Minitab software. The design of experiment was completely randomized design (full Factoriel). Also, to clarify the relationship between the characteristics of the Pearson correlation coefficient was used.

3. RESULTS AND DISCUSSION

3.1. Effects Q10 addition on pH and titrable acidity

Figures 4-9 shows the average pH, titrable acidity, Brix, viscosity, turbidity and general sensory acceptance of grape juice treatments during storage. Concentration of coenzyme Q10 and dual effect of temperature and time showed a significant effect on pH of grape juice. With increasing temperature and time, the pH was decreased. This may be due to the growth of acid-producing bacteria in fruit juice. Coenzyme Q10 concentrations also had a direct effect on the pH of juice and the reason may be the higher pH of Q10 and other accompanying materials (pH = 7) [8, 21]. Q10 concentration had a direct effect on pH (Figure 4). The results obtained revealed that the highest pH was for treatments A2B2C3 (containing 20 mg of Q10 in 300 mL of juice stored 25°C for 1 month) and the lowest pH was for treatment A2B4C1 (stored at 25°C for 3 months with no coenzyme Q10).

It was found that the factors of temperature, time and concentration of coenzyme Q10 had significant effect on the titrable acidity of the juice (Figure 5). Storage time and temperature had a direct effect on the titrable acidity of the juice, so that with increasing temperature and time acidity increased and with increasing concentrations of coenzyme Q10, the acidity was decreased. The concentration of coenzyme Q10 had reverse effect on titrable acidity, since acidity has a reverse relation with pH and according to the discussed reasons about pH changes, the numbers resulted about acidity seem to be normal [20]. The highest titrable acidity was for the treatments A1B4C1 and A2B4C1 (The both stored for 3 months with no coenzyme Q10), and the lowest was for the treatment A2B1C3 (At the start of storage at 25°C and containing 20 mg of coenzyme Q10 in 300 mL of juice).

3.2. Effect of adding Q10 on Brix and viscosity

It was determined that with increase of storing time and concentration of coenzyme Q10, Brix levels was increased due to increased dissolved solids. Only time and concentrations of Q10 showed significant effect while temperature had no effect. When storage time and concentration of Q10 increased, Brix was increased. The maximum Brix was for treatment A1B4C3 (containing 20 mg of Q10 in 300 mL of juice stored 4°C for 3 months), and the minimum Brix was for treatment A2B1C1 (At the start of storage at 25°C, with no coenzyme Q10) (Figure 6). In parallel with increase in storage time and concentration of Q10, juice viscosity was increased (Figure 7). This could be due to the interaction of juice particles with particles of Q10, or creation of small lumps in grape juice over time. Possible crystallization of sucrose and corn starch with coenzyme Q10 could also mention as a reason [21]. As the storage temperature increased, viscosity of grape juice was reduced because lower temperature (4°C compared to 25°C) resulted in a more condensing matrix with an increased density of the juice [21]. Also, at low temperature, the rate of crystallization and creation of small particles of crystals is increased. The maximum viscosity was for treatment A1B4C3 (containing 20 mg of Q10 in 300 mL of juice stored 4°C for 3 months), and the minimum viscosity was for treatment A2B1C1 (At the start of storage at 25°C, with no coenzyme Q10).

3.3. Effect of adding Q10 on turbidity

Results showed that storage time and concentration of coenzyme Q10 had a direct effect on grape juice turbidity. With increase of time and concentration of coenzyme Q10, turbidity was increased (Figure 8). The reason was associated with the grape color of Q10. Results revealed that with increase of temperature, turbidity of grape juice was reduced and the reason could be associated with the lower density of juice particles at higher

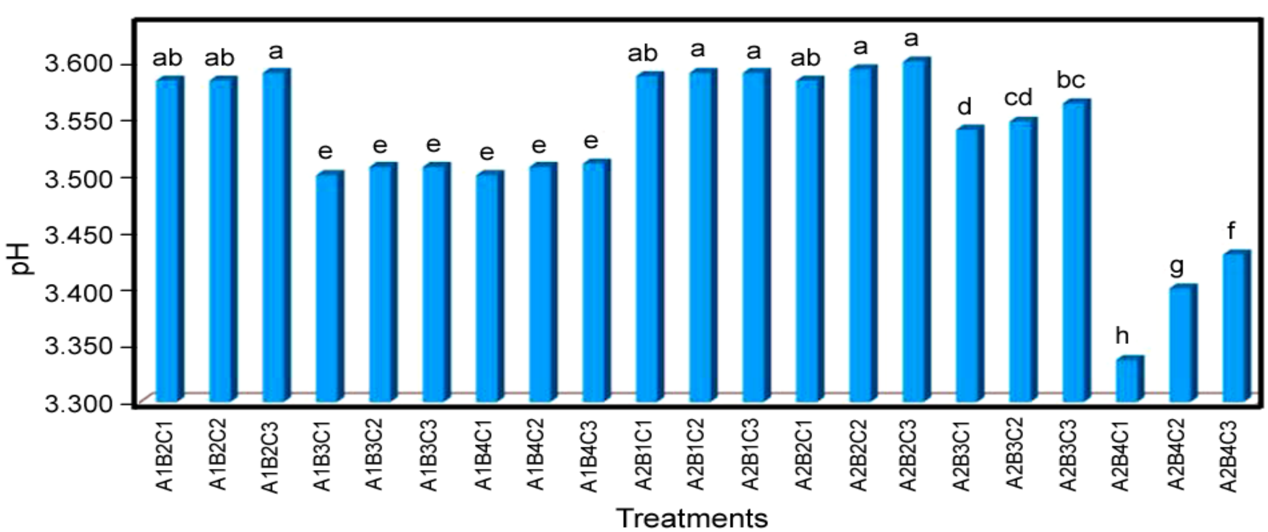

Figure 4: *Average pH of grape juice treatments during storage. Values displayed with different letters are significantly different. A = storage temperature (A1 = 4°C and A2 = 25°C); B = storage time (B1 = at the start of storage, zero, B2 = month 1, B3 = month 2, B4 = month 3); C = concentration of coenzyme Q10 in 300 mL of fruit juice (C1 = 0 mg/300 mL, C2 = 10 mg/300 mL, C3 = 20 mg/300 mL).*

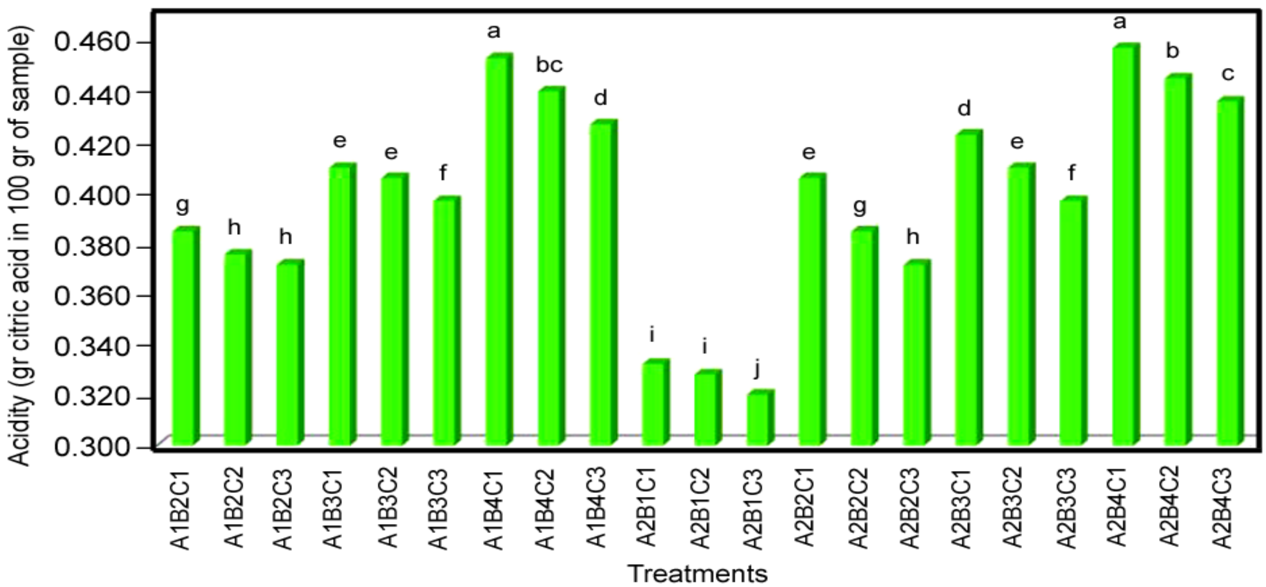

Figure 5: *Average acidity of grape juice treatments during storage. Values displayed with different letters are significantly different. A = storage temperature (A1 = 4°C and A2 = 25°C); B = storage time (B1 = at the start of storage, zero, B2 = month 1, B3 = month 2, B4 = month 3); C = concentration of coenzyme Q10 in 300 mL of fruit juice (C1 = 0 mg/300 mL, C2 = 10 mg/300 mL, C3 = 20 mg/300 mL).*

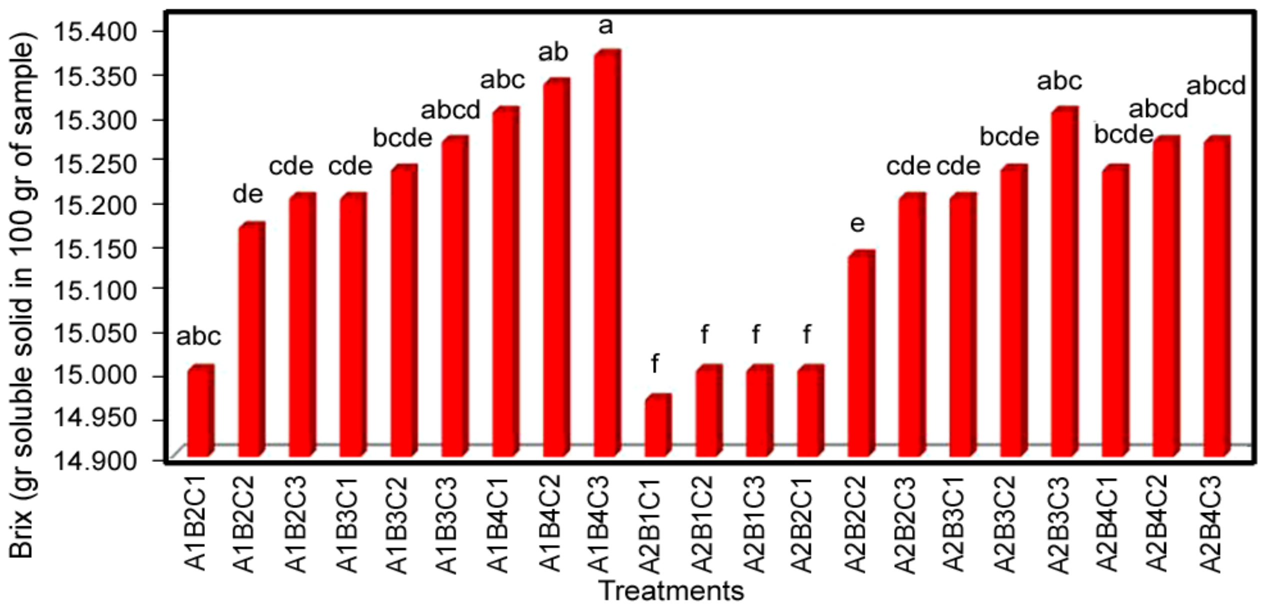

Figure 6: *Average Brix of grape juice treatments during storage. Values displayed with different letters are significantly different. A = storage temperature (A1 = 4°C and A2 = 25°C); B = storage time (B1 = at the start of storage, zero, B2 = month 1, B3 = month 2, B4 = month 3); C = concentration of coenzyme Q10 in 300 mL of fruit juice (C1 = 0 mg/300 mL, C2 = 10 mg/300 mL, C3 = 20 mg/300 mL).*

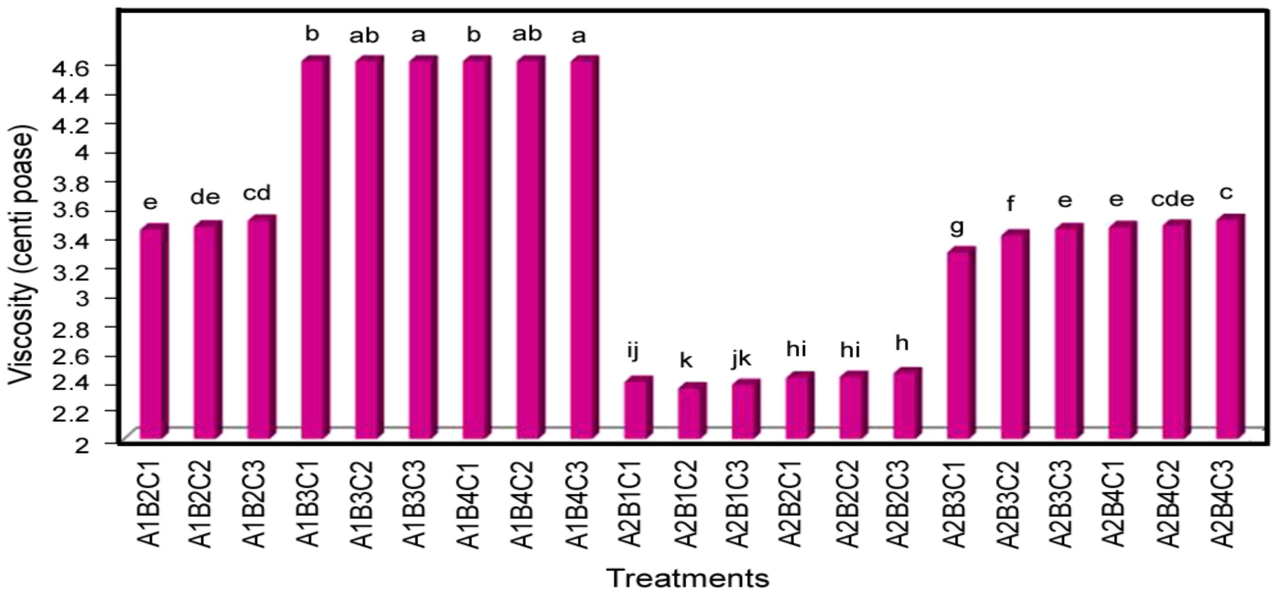

Figure 7: *Average viscosity of grape juice treatments during storage. Values displayed with different letters are significantly different. A = storage temperature (A1 = 4°C and A2 = 25°C); B = storage time (B1 = at the start of storage, zero, B2 = month 1, B3 = month 2, B4 = month 3); C = concentration of coenzyme Q10 in 300 mL of fruit juice (C1 = 0 mg/300 mL, C2 = 10 mg/300 mL, C3 = 20 mg/300 mL).*

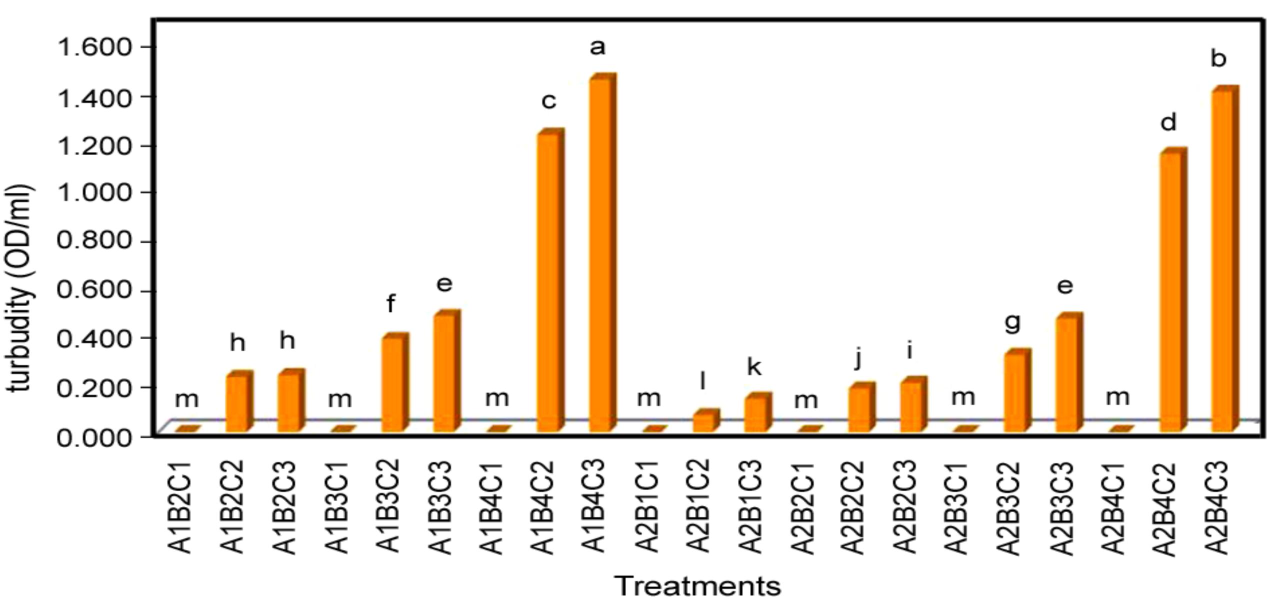

Figure 8: *Average turbidity of grape juice treatments during storage. Values displayed with different letters are significantly different. A = storage temperature (A1 = 4°C and A2 = 25°C); B = storage time (B1 = at the start of storage, zero, B2 = month 1, B3 = month 2, B4 = month 3); C = concentration of coenzyme Q10 in 300 mL of fruit juice (C1 = 0 mg/300 mL, C2 = 10 mg/300 mL, C3 = 20 mg/300 mL).*

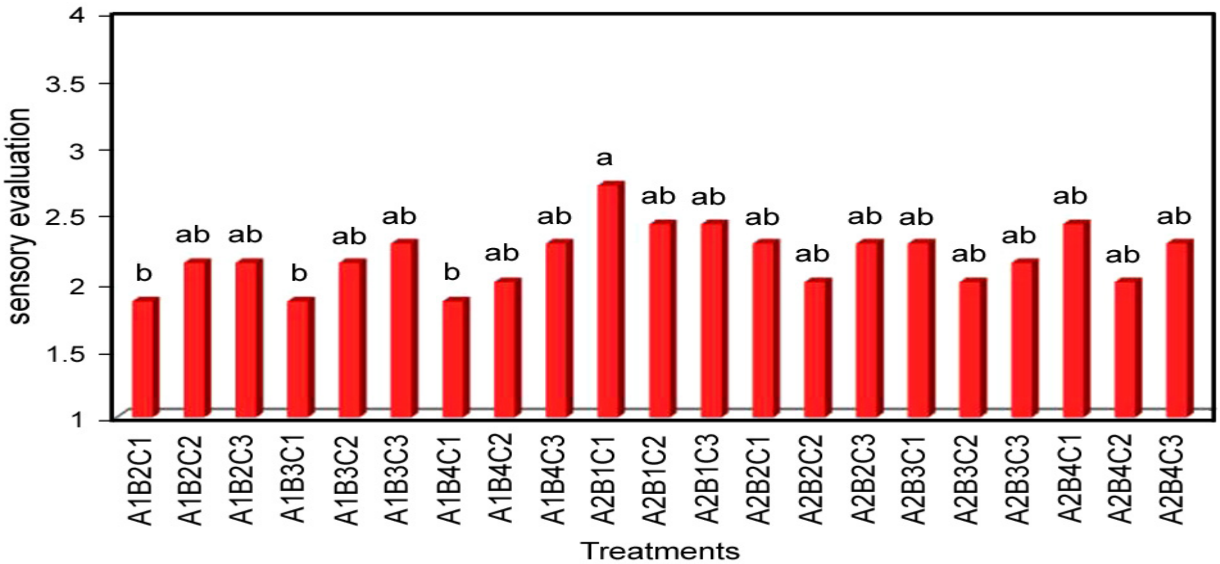

Figure 9: *General sensory acceptance of grape juice treatments during storage. Values displayed with different letters are significantly different. A = storage temperature (A1 = 4°C and A2 = 25°C); B = storage time (B1 = at the start of storage, zero, B2 = month 1, B3 = month 2, B4 = month 3); C = concentration of coenzyme Q10 in 300 mL of fruit juice (C1 = 0 mg/300 mL, C2 = 10 mg/300 mL, C3 = 20 mg/300 mL).*

Table 2: *Correlation between attributes in grape juice by pearson coefficient*

attribute	pH	acidity	brix	viscosity	turbidity
pH	1	-0.751 **	-0.485 **	-0.451 **	-0.408 **
acidity	-0.751 **	1	0.690 **	0.617 **	0.426 **
brix	-0.485 **	0.690 **	1	0.676 **	0.569 **
viscosity	-0.451 **	0.617 **	0.676 **	1	0.404 **
turbidity	-0.408 **	0.426 **	0.569 **	0.404 **	1

** = Difference between treatments is quite significant (P < 0/01).

temperatures [22]. The maximum turbidity was for treatment A1B4C3 (containing 20 mg of Q10 in 300 mL of fruit juice stored at 4°C for 3 months), while the minimum turbidity after the control was for treatment A2B1C2 (containing 10 mg of Q10 per 300 mL of juice, at the start of storage at 25°C). The Pearson correlation Table shows coefficients between physicochemical characteristics of the grape juice. As can be seen in the measured pH and other characteristics had an inverse relationship with each other while communicating with other characters straight (Table 2).

3.4. Effect of adding Q10 on total sensory acceptance

Most of treatments did not show significant difference in total sensory acceptance (Figure 9). The Transparency of juices kept at lower temperature (4°C compared those stored at 25°C) and samples with shorter storage time showed higher score. Mentioned facts could be due to lower unwanted interaction of coenzyme Q10 and other ingredients in system. The older samples had signi ficantly greater apparent turbidity. The changes in sensory parameters during the storage, although were significant, but fortunately, were not considerable.

4. CONCLUSIONS

Addition of coenzyme Q10 into food products can improve their functional characteristic due to its healthful effects. On the other hand, grape juice is a good vehicle for enrichment of Q10 because of its remarkable antioxidant capacity, anti-microbial and anti-fungal activity and having significant amounts of vitamin C, tannins and estrogen. The results of this study demonstrated that overall, addition of coenzyme Q10 in grape juice showed no considerable negative effects on the physico-chemical and sensory properties.

REFERENCES

1. Ernster L., Dallner G., *Biochem Biophys Acta*, **1271** (1) (1995), 195.
2. Crane F.L., *J Am Coll Nutr*, **20** (6) (2001), 591.
3. Quinzii C.M., Dimauro S., Hirano M., *Neurochem Res.*, **32** (2007), 723.
4. Alhasso S., *A review Hosp. Pharm.*, **36** (1) (2001), 51.
5. Kagan D., Madhavi D., *J Int. Med.*, **11** (2010), 109.
6. Littarru G.P., Tiano L., *An update Nutrition*, **2** (2009), 1.
7. Coles L., Harris S., *Adv Anti-Aging Med.*, **1** (1996), 205.
8. Pravst I., Prosek M., Wondra A.G., *Acta Chim Slov.*, **56** (2009), 953.
9. Itagaki Sh., Ochiai A., Kobayashi M., Sugawara M., Hirano T., Iseki K., *Food Chem.*, **120** (2010), 552.
10. Beketova N.A., Vrzhesinskaia O.A., Kosheleva O.V., Sharanova N.E., Soto S.K., Kulakova S.N., et al. *Vopr Pitan*., **795** (2010), 61.
11. Wang H., Cao G., Prior R.L., *J. Agric. Food Chem.*, **44** (1996), 701.
12. Davalos A., Bartolome B., Gomez-Cordoves C., *Food Chem.*, **93** (2005), 325.
13. Shankar S., Singh G., Srivastava R.K., *Front Biosci*, **12** (12) (2007), 4839.
14. Demrow H.S., Slane P.R., Folts J.D., *Circ*., **91** (1995), 1182.
15. Freedman J.E., Parker C., Li L., Perlman J.A., Frei B., Ivanov V., Deak L.R., Iafrati M.D., Folts J.D*., Circ.*, **103** (2001), 2792.
16. Jung K.J., Wallig M.A., Singletary K.W., *Cancer Lett*, **233** (2) (2006), 279.
17. Vinson J.A., Teufel K., Wu. N., *Atheroscl*, **156** (1) (2001), 67.
18. Acquaviva R., Russo A., Galvano F., Galvano G., Barcellona M.L., Li Volti G., *Cell Biol Toxicol.*, **19** (2003), 243.
19. Jayaprakasam B., Olson L.K., Schutzki R.E., Tai M.H., Nair M.G., *J. Agric. Food Chem.*, **54** (2006), 243.
20. Sadras V.O., Petrie P.R., Moran M.A., *Aust J Grape Wine Res.*, **19** (2013), 107.
21. Saravacos G.D., *J. Food Sci.*, **35** (2) (1970), 122.
22. Meyer A.S., Zeuner B., Pinelo M., *Food Bioprod Proc.*, **88** (2-3) 2010, 259.