

## Production of functional orange juice by the addition of coenzyme Q10

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### ABSTRACT

Today, in parallel to growing in acceptance of functional products, various additives are used to improve the characteristics of functional food products. The 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 orange 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.

**Keywords:** Coenzyme Q10; Orange juice; Physicochemical properties; Sensory evaluation

### 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 parabenzoquinone. The letter 'Q' refers to quinone chemical group and the digit '10' indicates the number of isoprenyl chemical subunits [2]. 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 [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]. 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. Among the juices, orange juice is confronted with a more welcoming feel by consumers and now 50% off the consumed juice in the world belongs to orange juice. Nutritive studies show that oranges are abundant source of vitamin

C and contain significant amounts of sugar, carbohydrates, flavonoids, essential oils and minerals. Orange contains high potassium and low sodium amounts. Sodium and potassium are responsible for regulating fluids in the body. Orange juice potassium is effective in preventing high blood pressure and can be good protection against brain and heart strokes. Because of this Orange is put in healthy food group by United States of America [11].

Orange juice is rich in folic acid, potassium and is an excellent source of phytochemicals, antioxidants and biological [12]. Orange juice can increase serum antioxidant capacity and oxidative stress compensation which is usually caused by foods high in fat and sugar [13]. Orange Juice is known as an anti-cancer agent due to kidney cancer treatment in rat. Orange juice is effective in the prevention and treatment of many types of cancer, including colon cancer, stomach cancer, lung cancer, breast cancer, prostate cancer, bladder cancer, esophageal cancer, cancer of the mouth, pharynx, larynx and nose, pancreatic cancer, cancer of the women genital, kidney cancer, thyroid cancer, skin cancer and cancer of the gallbladder [14].

It has been proven that Orange juice has a significant impact to help prevent and treat heart disease, lowering blood pressure and reducing cholesterol [15].

Studies on diseases of bones and joints, confirms the effect of orange juice in improving these diseases. Orange juice is effective in the prevention and treatment of osteoarthritis [16]. Orange juice is effective in improving diseases such as stroke, Alzheimer's, asthma, inflammatory bowel disease, gallstones, and has contributed to the overall public health [17]. Kurowska et al. (2000) found in their experiments that orange juice significantly reduces amount of cholesterol in patients with hyperlipidemia [18]. Alcada et al. (2009) also showed that orange juice increases the production of somatostatin which is an inhibitor of insulin secretion [19].

The aim of this study was to investigate the effects of adding coenzyme Q10 into orange juice on its some physicochemical properties and sensory attributes.

## **MATERIALS AND METHODS**

### ***Sample preparation***

Coenzyme Q10 (Sensus, Netherlands) added into 300 ml orange 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. Orange juice packs were kept in refrigerated temperature at two temperatures (4 or 25 ± 2 °C) for 3 months, per one-month intervals.

### ***Physicochemical analysis and sensory evaluation***

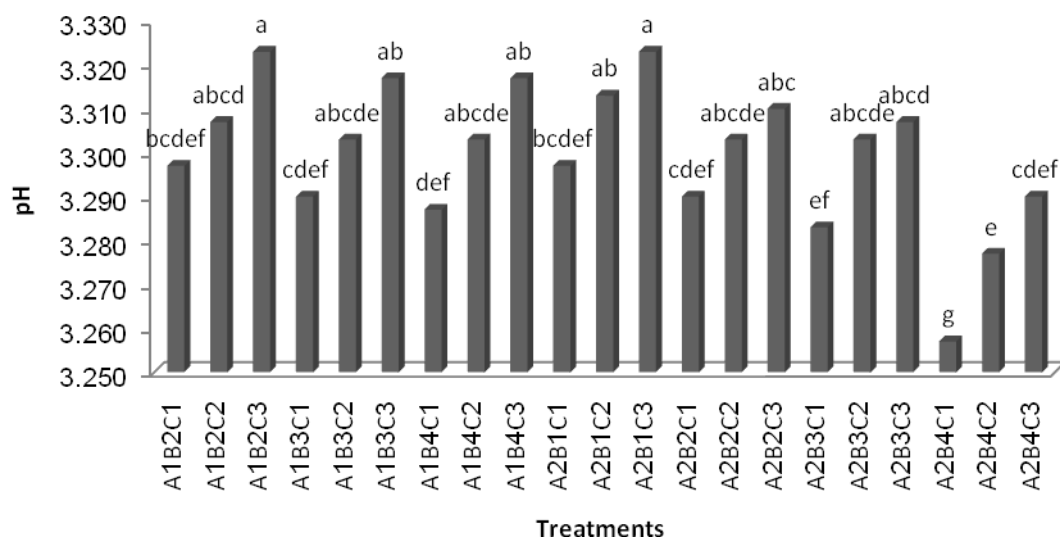
Measurement of the pH were done with a pH meter (Crison, Spain), Brix with a refractometer (Optech, Germany), viscosity with a viscometers (Brookfield, America), and turbidity with a spectrophotometer (Cromtech, Taiwan). Titrable acidity was measured via titration method. Sensory characteristics of the 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 Factorial).

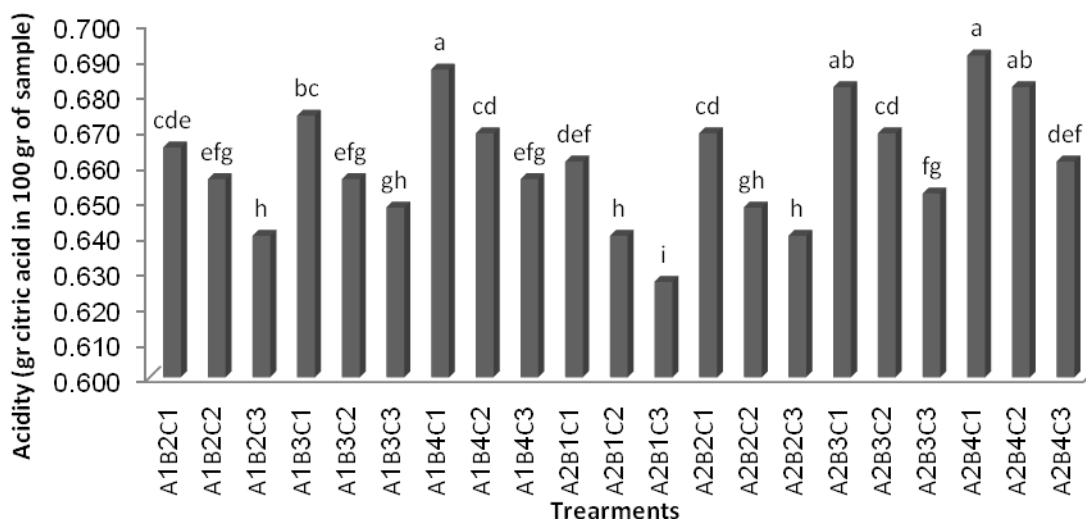
## **RESULTS**

### ***Effects Q10 addition on pH and titrable acidity***

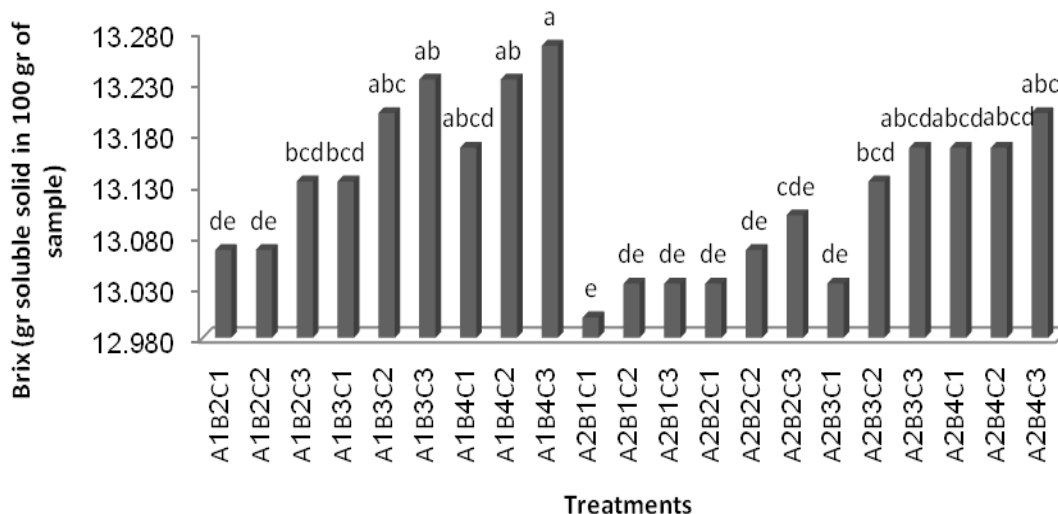
Figures 1-6 shows the average pH, titrable acidity, Brix, viscosity, turbidity and general sensory acceptance of orange juice treatments during storage. Concentration of coenzyme Q10 and dual effect of temperature and time showed a significant effect on pH of orange juice. With increasing temperature and time, the pH was decreased. Q10 concentration had a direct effect on pH (Figure 1). The results obtained revealed that the highest pH was for treatments A1B2C3 and A2B1C3 (The both containing 20 mg of coenzyme Q10 in 300 ml of juice) 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 (Figure2).



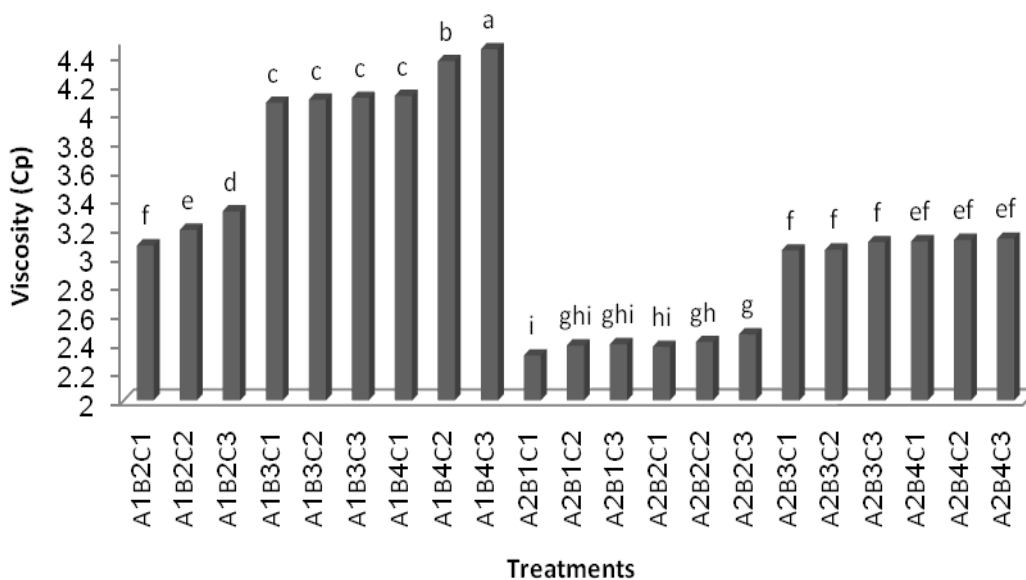
**Figure 1.** Average pH of orange juice treatments during storage. Values displayed with different letters are significantly different. A = storage temperature (A1 = 4 °C and A2 = 25 °C); B = storage time (B1 = at the start of storage, zero, B2 = month 1, B3 = month 2, B4 = month 3); C = concentration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



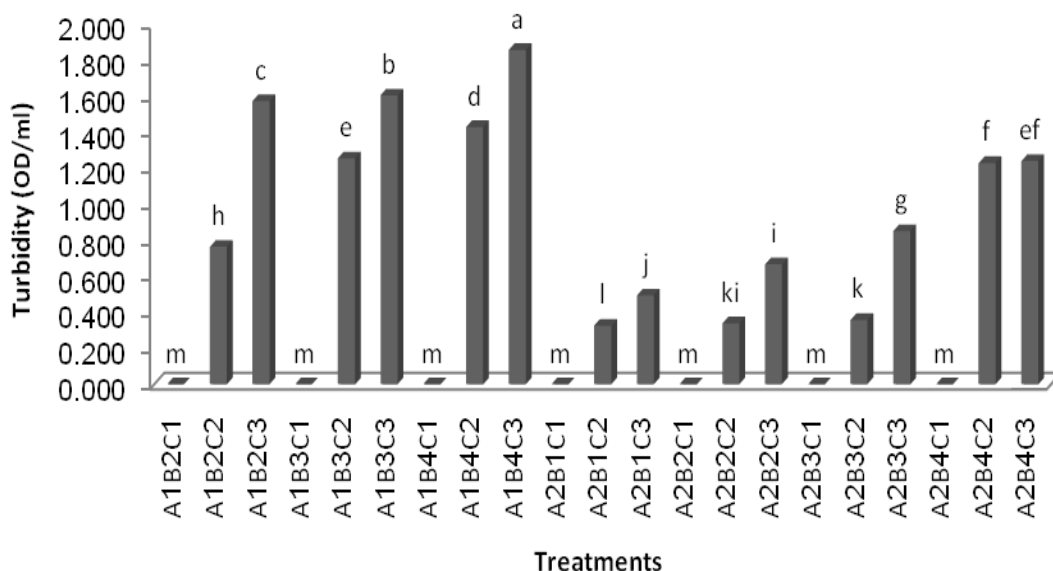
**Figure 2.** Average acidity of orange juice treatments during storage. Values displayed with different letters are significantly different. A = storage temperature (A1 = 4 °C and A2 = 25 °C); B = storage time (B1 = at the start of storage, zero, B2 = month 1, B3 = month 2, B4 = month 3); C = concentration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



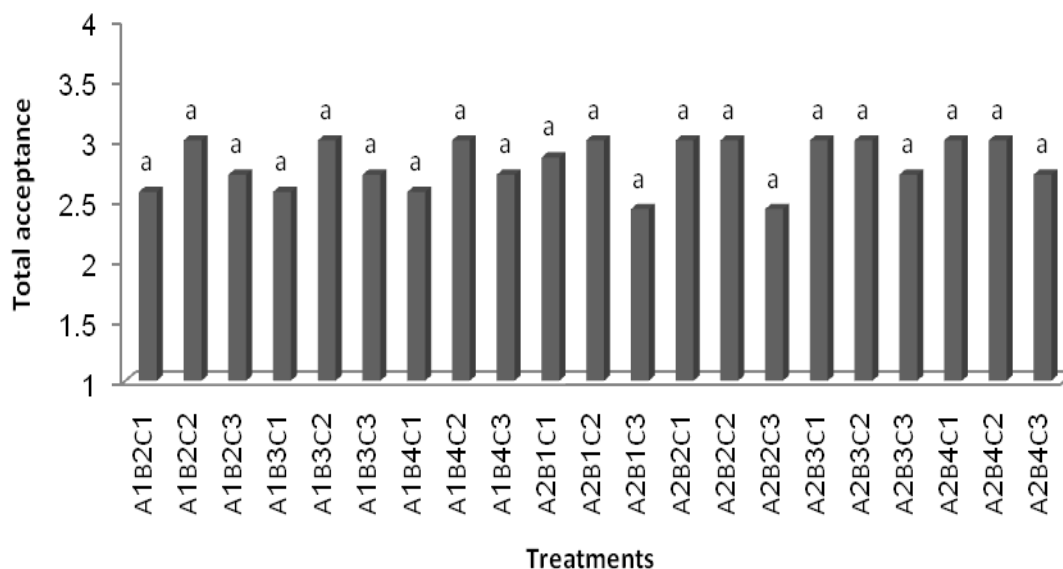
**Figure 3.** Average Brix of orange juice treatments during storage. Values displayed with different letters are significantly different. A = storage temperature (A1 = 4 °C and A2 = 25 °C); B = storage time (B1 = at the start of storage, zero, B2 = month 1, B3 = month 2, B4 = month 3); C = concentration 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 4.** Average viscosity of orange 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 turbidity of orange 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.** General sensory acceptance of orange 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).

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 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).

#### ***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. 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 3).

In parallel with increase in storage time and concentration of Q10, juice viscosity was increased (Figure 4). As the storage temperature increased, viscosity of orange juice was reduced. 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).

#### ***Effect of adding Q10 on turbidity***

Results showed that storage time and concentration of coenzyme Q10 had a direct effect on orange juice turbidity. With increase of time and concentration of coenzyme Q10, turbidity was increased (Figure 5). The reason was associated with the orange color of Q10. 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).

#### ***Effect of adding Q10 on total sensory acceptance***

Most of treatments did not show significant

difference in total sensory acceptance (Figure 6). The color of juices kept at lower temperature (4 °C compared those stored at 25 °C) showed higher score. Also, samples with longer storage time had lower score in taste, aroma and overall acceptability. The older samples had significantly greater apparent turbidity.

## **DISCUSSION**

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]. 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].

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. With increase in storage time and concentration of Q10, juice viscosity was increased. This could be due to the interaction of juice particles with particles of Q10, or creation of small lumps in orange 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 orange 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.

With increase of time and concentration of coenzyme Q10, turbidity was increased (Figure 5). The reason was associated with the orange color of Q10. Results revealed that with increase of

temperature, turbidity of orange juice was reduced and the reason could be associated with the lower density of juice particles at higher temperatures [22]. In sensory parameters, the color of juices kept at lower temperature (4 °C compared those stored at 25 °C) showed higher score. Also, samples with longer storage time had lower score in taste, aroma and overall acceptability. Mentioned facts could be due to lower unwanted interaction of coenzyme Q10 and other ingredients in system. The older samples had significantly greater apparent turbidity. The changes in sensory parameters during the storage, although were significant, but fortunately, were not considerable.

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## CONCLUSION

Addition of coenzyme Q10 into food products can improve their functional characteristic due to its healthful effects. On the other hand, orange 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 orange juice showed no considerable negative effects on the physicochemical and sensory properties.

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