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SOLUBLE SUGAR CONTENT AND pH IN CARROT'S ROOT JUICE

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Abstract

Carrot (Daucus carota L.*) is vegetable of Apiaceae family that has a very significant nutritional and health value in human nutrition. Furthermore, it is rich in elements that alkalize blood and keeps it at pH 7. Therefore, the aim of this research was to determine the content of soluble sugars and pH in carrot's juice and to compare the results regarding to the place of purchase. Carrot sampling was carried out in triplicate in city of Zagreb (Croatia) in 5 retail chains, 5 markets and 5 organic products stores. Soluble sugar content (% Brix) from the percolated juice was determined by refractometer, while the pH of the juice was determined by pH meter. The content of soluble sugar ranges between 6.47 and 10.13% Brix (average 7.43 in supermarkets, 7.95 in markets and 8.54 in organic shops). The pH of the carrot juice ranges from 6.17 to 7.02 (average 6.69 in supermarkets, 6.65 at markets and 6.55 in organic shops).*

Key words*: copper, Daucus carota* L.*, iron, manganese, zinc.*

INTRODUCTION

Carrot (*Daucus carota* L.) is a vegetable crop of the *Umbelliferae* family, grown primarily for its thickened and nutrient-rich root or hypocotyl. Due to the wider possibility of use in raw, fresh and processed form, as well as due to the nutritional values recognized in the food industry, it is one of the most important vegetable species and its potential is recognized not only in the food industry but also in other industries (Lešić et al., 2002).

A diet rich in processed foods acidifies the human body, which in optimal conditions should be within neutral pH. Carrot juice is recommended by many nutritionists as a valuable dietary supplement precisely because it is rich in alkaline elements that alkalize human blood and keep it at pH 7-8, and does not contribute to increased sugar blood level because it has a low glycemic index and low caloric value.

According to Schaller (1999) different varieties of carrots have different proportions of total sugars. In addition to genetic predispositions, sugar content is determined by environmental factors too. Sucrose, glucose and fructose make up 99% of the available carbohydrates in carrot. Sucrose is a storage carbohydrate of carrot root. It is synthesized in the process of photosynthesis in the leaf, after which it is transported to other plant organs, where is reduced to monosaccharides. Carrot absorbs a lot of potassium, so fertilizing with potassium-rich fertilizers, moderate-rich nitrogen fertilizers and sufficient exposure to sunlight will increase the intensity of sucrose synthesis as well as the storage of sugar in the root.

Bach et al. (2015) state that glucose, fructose, and sucrose were identified as individual sugars present in carrots. Sucrose is the most abundant sugar and makes up 57-69% of the total sugar content, while glucose and fructose make up 16-22% and 15-22% of the total content, respectively.

Schaller (1999) further states that in the vegetative phase of development, the sucrose content increases with maturity and growth time. In the post-harvest period, disaccharides are again reduced to monosaccharides and metabolized. The intensity of metabolism depends largely on the storage temperature. Research shows that carrot need a temperature of 0-2°C with high humidity for storage.

According to Bender et al. (2009) organically grown carrot contain more sugar than conventional ones, while differences in certain minerals are negligible.

The glycemic index (GI) is a scale for determining the rate of increase in a person's blood glucose level after consuming a particular food. The scale is ranked from 0 to 100. Foods that are rich in carbohydrates and easily digested cause a rapid rise in blood glucose levels. GI is particularly important given that the population is affected by chronic diseases such as diabetes and insulin resistance. The GI of fresh carrot is 30, while cooked 85. In addition, research by Gustafsson et al. (1995) studied the relationship between satiety and higher energy value of carrot-rich meals. It has been shown that the lower the reaction of glucose and insulin/C-peptide, the greater the feeling of satiety and that the minimum need is actually 200 g of carrot. But different preparations gave different results. Fresh carrot achieves greater satiety, but also a greater reaction of glucose and C-peptide in contrast to cooked carrot. Therefore, according to the recommendations of nutritionists, fresh carrot should be consumed to achieve a feeling of satiety, and sugars that are absorbed are consumed faster and are not stored in the form of fat.

Carrot, like all other types of fruits and vegetables, contain a large number of organic acids. According to the level of concentrations, malic and citric acids are distinguished with succinic, fumaric and tartaric acid, but they are found in low concentrations (Schaller, 1999).

However, high pH makes the juice more susceptible to spoilage and contamination by microorganisms, therefore for easier storage it is either mixed with juice of lower pH (apple, orange) or acids are added directly. Sinchaipanit and Kerr (2007) showed that the pulp size, diameter 332-283 μm, juice has no effect on pH and content of soluble dry matter, and that in pasteurized juice these values remain the same through two weeks of refrigeration. Homogenization of the samples had the greatest effect on viscosity, while other factors such as pH and soluble dry matter had no effect.

Schultz et al. (2014) state that reduced pH of the juice causes visually clear juice due to particle flocculation. Cloud stability decreases reciprocally with decreasing pH while particle size increases with decreasing pH. The effect of the added *Aframomum danielli* extract in carrot juice provided insight to into a new way of preserving said juice (Amanyunose et al., 2017). The high pH value (6.4) in the juice treated with 15% extract on the first day, resulted in low acidity thus characterizing the juice as a food with a low acid content. Thus, the addition of *A. danielli* extract increases the acidity of the juice at room temperature.

According to Reiter et al. (2003) acidification of juice causes coagulation of juice particles by the reaction of acid-sensitive proteins, which in their study takes place at pH 4.4. Nadulski et al. (2015) as part of their research also observed physical changes in freezing and thawing of carrot juice, where the established results showed that there were no significant changes in pH values (pH 6.35 was determined as the lowest value, while pH 6.53 was the highest). Türkmen and Takci (2018) investigated the influence of ultraviolet B and C rays on carrot juice, where one of the conclusions is that exposure of juice to ultraviolet rays does not cause significant changes in pH. The determined pH value of the control treatment is 6.34, for juices exposed to UV-C rays the reaction varied in the range between 6.31 and 6.39, while for juices exposed to UV-B rays between 6.28 and 6.54.

Da Silva et al. (2007) state in freshly squeezed juice a pH range of 6.01 to 6.14 while Demir et al. (2007) pH 6.2.

Therefore, the aim of this study was to determine the content of soluble sugars and pH in carrot juice and to compare the results according to the place of purchase.

MATERIALS AND METHODS

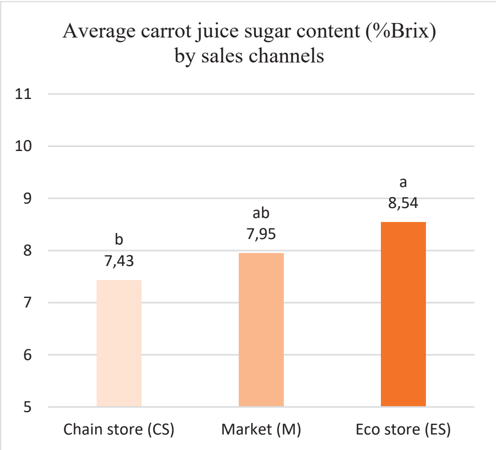
Samples of fresh carrots (orange root coloured) were collected in city of Zagreb (Croatia) on 4 Dec 2017. The sampling places represented different selling channels: chain stores, markets and organic products stores. Chain stores (CS) were represented by following selling points: CS1-Konzum, CS2-Lidl, CS3-Kaufland, CS4-Plodine, CS5-Spar. Markets (M) were represented by following selling points: M1-Britanski trg, M2-Branimirova, M3-Dubrava, M4-Dolac, M5-Kvatrić. Organic products stores (Eco stores; ES) were represented by following selling points: ES1-Priroda i društvo,

ES2-Garden, ES3-Grga čvarak, ES4-Biovega (bio&bio), ES5-Eko Sever.
It was randomly chosen 5 of each selling point, where the samples were sampled in triplicate.
Information on carrot cultivation was obtained at the point of sale (insight into the declaration or oral communication with sellers). As carrot samples from retail chains did not have the label that they are organic products, it is assumed that their cultivation is conventional, which presupposes the use of mineral fertilizers in carrot cultivation. According to sellers, cattle manure was used for growing carrots collected at the Britanski trg and Dolac markets, mineral fertilizer was used for growing carrots collected at the Dubrava and Kvatrić markets, and sheep manure was used for growing carrots collected at the Branimirova market. Carrots, collected in organic products stores, are from organic farming, because only products of certified organic origin are sold in these stores.
Collected carrot samples were peeled and cleaned of rotten parts, after which they were chopped and ground. The juice was squeezed with a press, in which a soluble dry matter (% Brix) was determined using the digital refractometer, and the pH value of carrot juice was determined using the pH meter.
The samples, collected in triplicate, were analysed individually and the results showed average values. Statistical data processing followed the variance analysis model (ANOVA). The SAS System for Win program was used. version 9.1 (SAS Institute Inc.), and Tukey's significance threshold test (SAS, 2002-2003) was used to test the results.

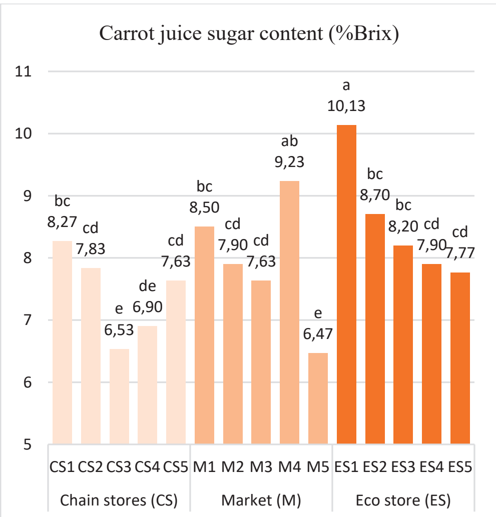
RESULTS AND DISCUSSIONS

Graph 1 shows the mean value of the soluble sugar (sugar) content in the analysed carrot juices according to sales channels, expressed in % Brix.
Statistically, the highest sugar content (8.54% Brix) was found in organic carrot juice, sampled in organic products stores, while statistically the lowest sugar content (7.43% Brix) was found in conventional carrot juice, sampled in chain stores.
Observing the Graph 2, it is determined the variation in the sugar content between 6.53 and 8.27% Brix in carrots from chain stores, 6.47 to 9.23% Brix in carrots from markets and 7.77 to 10.13% Brix in carrots from trade in organic products stores. The highest value was found in carrots sampled in the organic products store, Priroda i društvo (10.13% Brix), while the lowest value was found in carrots sampled at the Kvatrić market (6.47% Brix).
The obtained values match the literature citations looking at the mean value. The study by Gills et al. (1999) showed that depending on the carrot variety % Brix varies between 7.8 to 10.0, with the fact that the percentage sugar content is not directly related to the sweet taste of carrots. In one of the cultivars, which proved to be the sweetest in taste, a high % of Brix was found, but with the least sugar content. Significant differences existed in the perception of sweet taste as well as in the % Brix and the sugar content. However, the observed sweetness intensity was not related to % Brix or to the sugar content.
Da Silva et al. (2007) reported that % Brix, depending on the cultivars tested, ranged from 8.45 to 9.61. On the other hand, the research of Bender et al. (2009) showed that the difference in the total sugars content in conventional and organically grown carrots (6.5 and 6.0 % Brix) is not significant. Furthermore, Kaack et al. (2002) found 8.6 to 9.2% Brix in organically grown carrots and 5.0 to 9.1% Brix in carrots from conventional cultivation. The mean value in both cultivation methods was 8.9% Brix.
Graph 3 shows the mean pH of the juice of the analysed carrots according to sales channels. The mean pH of all juices is 6.63. Although the differences are not statistically significant, the relatively highest pH value is found in carrot juice from chain stores (pH 6.69), while the lowest value was found in carrot juices from organic products stores (pH 6.55).
Graph 4 shows all the obtained pH values where it can be seen that the pH of carrot juice sampled in chain stores varies between 6.49 and 7.01, sampled at markets 6.31 and 6.92 and sampled in organic products stores 6.17 and 7.02. The statistically highest pH value (7.02) was found in carrot juice purchased at Garden, an organic products store, while the statistically lowest pH value (6.17) was found in carrot samples purchased at the Grga Čvarak store, which is also an organic products store.

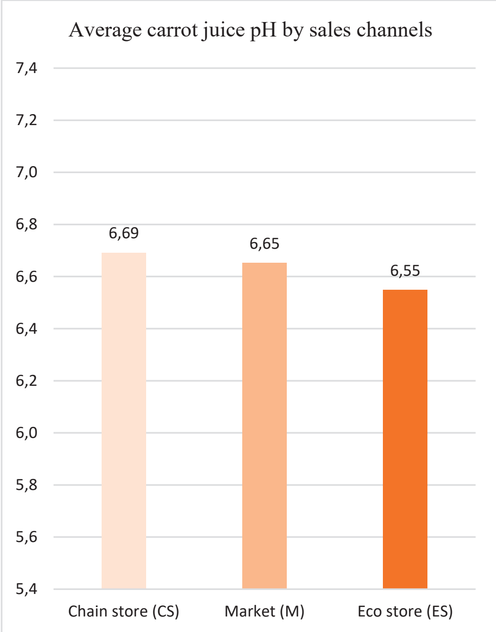
According to Gopalakrishnan (2007) due to low concentrations of organic acids, the reaction (pH) of carrots varies between 6 and 7. Da Silva et al. (2007) reported pH results ranging from 6.01 to 6.14, while in a study by Demir et al. (2007) pH was 6.2, and it is evident that the values determined from this study coincide with the literature data.



Graph 1. Average carrot juice soluble sugar content (%Brix) by sales channels
Different letters represent significantly different values according to Tukey's test, p≤0.05. The non-letter values are not significantly different



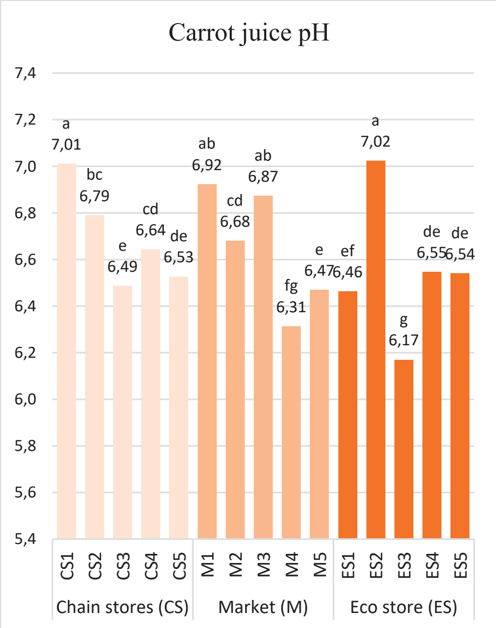
Graph 2. Carrot juice soluble sugar content (%Brix) by selling points
Different letters represent significantly different values according to Tukey's test, p≤0.05. The non-letter values are not significantly different



Graph 3. Average carrot juice pH by sales channels
Different letters represent significantly different values according to Tukey's test, p≤0.05. The non-letter values are not significantly different

CONCLUSIONS

The soluble sugar content (% Brix) in carrot juice ranged from 6.24 to 10.13% Brix (7.43 for carrots in chain stores, 7.95 for carrots at markets and 8.54 for carrots from organic products stores). According to the obtained results, it is visible that the juice from organic products stores has the largest soluble sugar content, while the lowest soluble sugar content was found in carrot juice from chain stores.
The reaction (pH) of carrot juices varied between 6.17 and 7.02 (6.69 in carrots from chain stores, 6.65 in carrots from markets and 6.55 in carrots from organic products stores). The obtained results show that the pH differences between the juices are not significant.
Regardless of the method of cultivation, the results showed that a slightly acidic to moderate juice reaction



Graph 4. Carrot juice pH by selling points
Different letters represent significantly different values according to Tukey's test, p≤0.05. The non-letter values are not significantly different.
(pH) is a property characteristic of carrots and that the soluble sugar content is a property that is related to the variety and method of cultivation

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