Journal homepage: www.fia.usv.ro/fiajournal
Journal of Faculty of Food Engineering,
Ştefan cel Mare University of Suceava, Romania
Volume XV, Issue 3- 2016, pag. 259 - 265

ANALYSIS OF PHYSICAL PARAMETERS OF NATURAL JUICES

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Received August 7th 2016, accepted September 27th 2016

Abstract: *The purpose of this paper was to investigate the change in density, electrical conductivity, pH, refractive index, dry soluble solids, as well as the parameters specific to the color of natural juices stored at + 4°C and normal atmospheric pressure in two types of containers. The physical parameters were determined immediately after the obtaining of juice, at 2 days and 5 days of storage respectively. From the analysis of experimental results, there is an increase in density, in all samples, while the pH changes only slightly for the orange juice. Storage at temperatures of + 4°C reduces the risk of contamination and decreases speed of biochemical changes, but it is not sufficient to guarantee the nutritive and organoleptic qualities of the juice and its acceptability by the consumer.*

Keywords: *electrical conductivity, pH, refractive index, color, juice.*

1. Introduction

Physical and chemical analyzes of fruit and vegetables juices (density, electrical conductivity, pH, refractive index, dry soluble solids), and the parameters specific for the color, represent investigating methods of the beverage quality examined to storage at the temperature of 0 - +4°C and normal atmospheric pressure in various kinds of container on a period of up to five days. Knowing the physical parameters is very important in determining the optimum storage conditions of fruit and vegetables juices, the sizing of storage and the conditioning installations. Specific parameter values of fruit and vegetables juices and concentrates are useful in preparing thermal balance.

Current requirements of consumers are turning to juices of superior quality that are cheap, with nutritional value, flavor, texture and a color corresponding to fresh fruits without chemical preservatives and yet wholesome and safe.

Keeping juices at low temperatures is carried out in order to preserve them (prevents fermentations). Refrigeration is used to temperatures between -5ºC and +5ºC without changing the state of aggregation and the freezing temperatures are used between -10ºC and -30ºC [1-2]. Using artificial cold for the processing, storage and marketing of perishable foods is a method widely used in almost all branches of food industry. Due to its preservative and inhibitory action on agents that cause degradation, cold artificial processes used in refrigeration, freezing or freeze-drying [1]. Refrigeration operation comprises two phases, the actual refrigeration (cooling from the initial temperature to the storage temperature) and keeping the refrigeration. It has been found that by lowering the temperature of juice from 25 - 30ºC to 0ºC, the preservation period is increased to approximately 15 times [2].

Fruits are particularly valuable for the content of carbohydrates, vitamins, minerals, pigments and other biologically active substances. Fruits have an alkalizing effect in the body (like vegetables) and they represent the food that influence the health of the organism and reduce the risk of chronic diseases. Fruits rich in carbohydrates are contraindicated for diabetics and overweight people, but also healthy people with normal weight should not consume excess. They are suitable for children and athletes who require immediate energy. Vegetables are an important source of vitamins, minerals, carbohydrates (~ 5% for leafy vegetables and 10 - 12% for root vegetables, melons, Solano fruiting), fiber (1 - 2%), and other biologically active substances [3]. Vegetable juices with pulp can be used to feed infants from the age of 4 months as excellent sources of minerals and vitamins. The most commonly used juices are: carrots, tomatoes and beetroot, alone or in combination with each other and with other vegetable juices: parsley, spinach, celery [4].

The researches presented in this paper followed the variation of density, electrical conductivity, pH, refractive index, and the parameters specific for the color of orange (*Citrus sinensis*), lemon (*Citrus limon*), kiwi (*Actinidia chinensis*), carrot (*Daucus carota*) and beet (*Beta vulgaris*) juices stored at +4ºC and normal atmospheric pressure in two types of container (a brown bottle and polyethylene terephthalate, respectively) at 2 days and 5 days of storage respectively.

The main objective of this survey is to investigate the change in density, electrical conductivity, pH, refractive index, dry soluble solids, as well as the parameters specific for the color of natural juices stored at +4°C and normal atmospheric pressure in two types of container.

2. Matherials and methods

2.1. Samples and equipment

Juices were prepared from fruits and vegetables purchased from the local market in Suceava, Romania, using a Vital juicer and they were divided into 25 samples, from which 5 were analyzed immediately and the remaining 20 samples were stored individual in brown glass containers respectively polyethylene terephthalate (PET) opaque in the cooler at +4ºC and normal atmospheric pressure. Samples of fruit and vegetables are coded according to *Table 1*.

Equipment used was from the Food Safety Research Center of the Faculty of Food Engineering, Stefan cel Mare University of Suceava, Romania.

Table 1.

Coding the juice samples studied

Type of juice	Coding				
	Fresh juice	Juice stored 2 days		Juice stored 5 days	
		Brown glass bottle	PET container	Brown glass bottle	PET container
Orange (*Citrus sinensis*)	**1**	**2**	**3**	**4**	**5**
Lemon (*Citrus limon*)	**1**	**2**	**3**	**4**	**5**
Kiwi (*Actinidia chinensis*)	**1**	**2**	**3**	**4**	**5**
Carrot (*Daucus carota*)	**1**	**2**	**3**	**4**	**5**
Beet (*Beta vulgaris*)	**1**	**2**	**3**	**4**	**5**

2.2. Determination of density

Density of juices was calculated by using density determination kit (XA, RADWAG) of analytical balance (Partner XA 160).

2.3. Determination of conductivity and pH

Conductivity of juices were determined by using a conductivity meter (Accumet XL30, Fisher Scientific) and the pH of samples was measured with a calibrated digital pH meter (HQ11d pH by HACH), by the glass electrode being immersed in samples.

2.4. Refractive index and % solids measurement

Refractive index (n_D) and % solids in juices were measurement by using Abbe Refractometer (Leica MARK II PLUS). The dry soluble solids content (% solids) of a sample is estimated from its refractive index, with reference to the refractive index of a pure sugar solution. The refractive index is proportional to the solution concentration (following the theory of Lorentz and Lorenz). In fruit juices the refractive index is therefore dependent upon sugar concentration and also upon the concentration of other soluble materials (organic acids, minerals, amino acids etc.).

2.5. Color measurement

The color measurement involves the determining of the reflection spectrum of a sample and applying it to a standard illuminant. The amount of light energy the sample reflects is manipulated and reduced to tristimulus values X, Y and Z. These values correspond to the physiological response of the three types of color receptors in the human eye. X, Y and Z values are combined into the uniform color space values such as L^*, a^* and b^* [5-6]. The *Chroma*, considered a quantitative attribute of coloring, is used to determine the difference degree of a hue in comparison with a grey color of the same luminosity. The description of a color using the *hue* (h^*) attribute refers to how humans perceive an object's color - red, orange, green, blue, etc. A 0º or 360 º angles represent the red hue, while angles of 90º, 180º and 270º represent yellow, green and blue hues [7-8]. ΔE^* – represents the color difference magnitude between the value of the initial color and the value of the final color and gives the distance between the points representing the color, being calculated according to the equation:

$$\Delta E^* = \sqrt{\Delta a^{*2} + \Delta b^{*2} + \Delta L^{*2}} \qquad (1)$$

Within the study, the HR 4000 CG-UV-NIR spectrometer (Ocean Optics Inc., Dunedin, FL) which is based on the reflection property of samples was used. In this respect, a scanning with 0.025nm resolution has been carried out for the entire wavelength spectrum ranging from 200 up to 1100 nm. A tungsten halogen light source (UV-VIS-NIR Light Source DH-2000, Mikropack) was used in this study. The experimental data was displayed and stored using the operating software OOI Base32 including OOIColor from Ocean Optics. The light from Light Source DH-2000 was focused to the sample through an array of optical fibres (QR400-7-UV/BX, Ocean Optics Inc., Dunedin, FL). Reflectivity was measured as against a reference standard – WS- Diffuse Reflectance Standard [5-6].

2.6. Statistical Analysis

All the assays were conducted at least in duplicate, and the results were expressed as the mean ± standard deviation. Statistical significance was accepted at $p < 0.05$.

3. Results and discussion

According to *Figure 1 a)*, from the analysis of experimental results, there is an increase in density over time, for all samples. The highest increase was observed for beet, while the lowest variation was observed in carrot. Also, analyzing the behavior depending upon the nature of juice container, it can be seen an increase in density for kiwi and lemon juice stored in a brown glass bottle compared to the PET container. For the beet juice there is a greater variation in sample density packaged in PET.

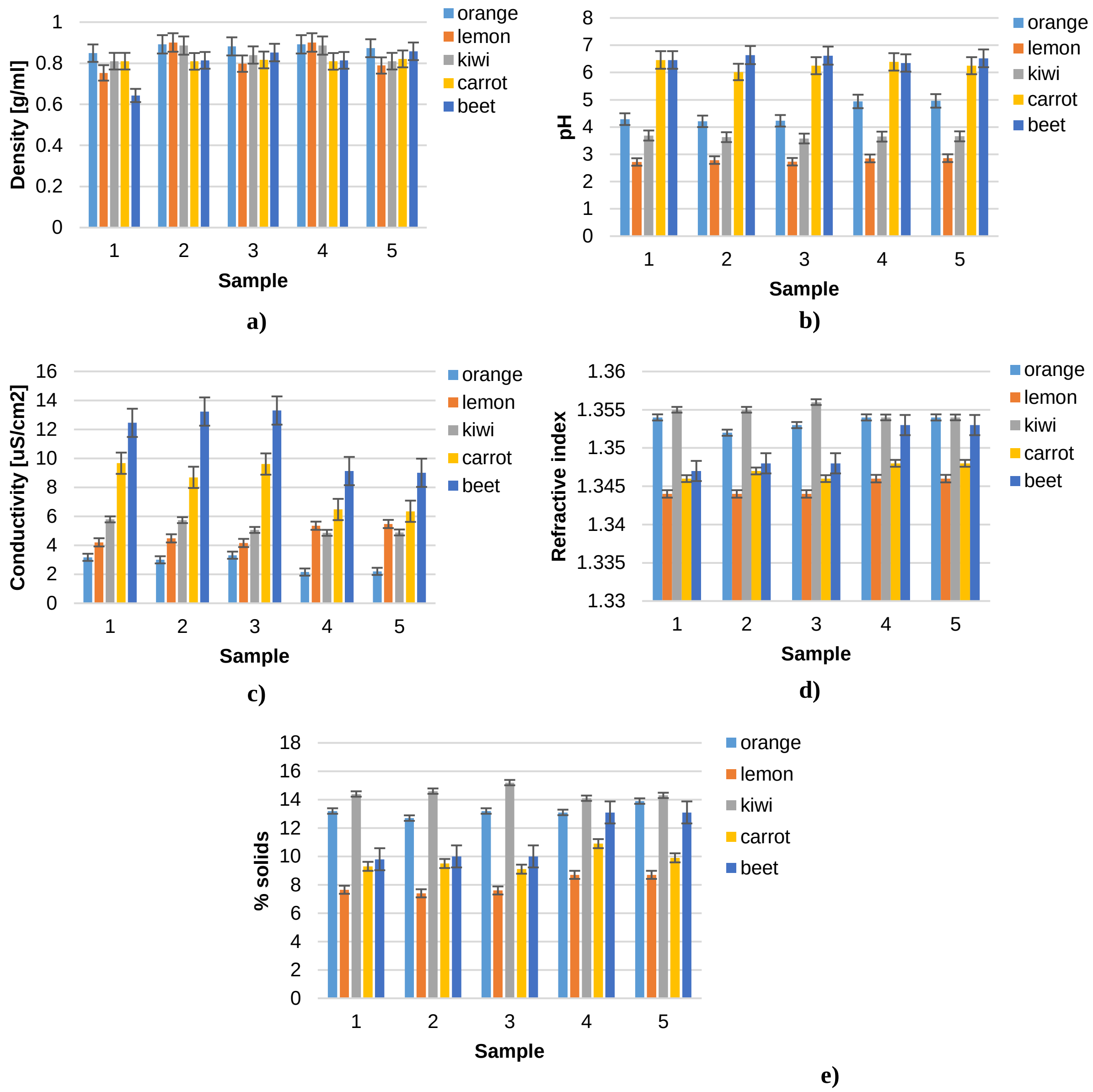

Figure 1. Variation a) density, b) pH, c) conductivity, d) refractive index, e) dry soluble solids for the analyzed juice samples

From the analysis of experimental results, according to *Figure 1 b)*, there is an increase in pH only for orange juice, while neither for the other juices is nor observed its variation neither is observed the pH dependence upon the nature of the container.

There is a decrease in conductivity at the samples analyzed in time, from the analysis of experimental results, according to *Figure 1c)*. We can observe the biggest variation in the carrot juice and beet juice and the least for kiwi. There are no changes in conductivity for samples **2** (juice stored 2 days in brown glass bottle) and **3** (juice stored 2 days in PET container) or samples **4** (juice stored 5 days in brown glass bottle) and **5** (juice stored 5 days in PET container) where we conclude that conductivity is not influenced by the container material. For orange and kiwi is irrelevant.

Many people consume fruit juices on a daily basis. Fruit juices are a convenient way for people to receive the benefits of various fruits. However, they may also have high sugar content. Although the sugar is natural, it may not be healthy in high quantities. It was suggested that too much sugar could pose harmful health effects, as people could develop diabetes, obesity, heart disease, and other complications from excess consumption [9]. A significant variation is found from the analysis of experimental results for beet, carrot and lemon juices and irrelevant for orange and kiwi juices, according to *Figure 1 d)* and *e)*, for the refractive index and dry soluble solids.

In the food industry, colour is a quality attribute that affects consumers in terms of choice and food preferences. From the physical point of view, the colour is a numerical expression which is evaluated as the difference in colour against a known standard. Instead, from the consumer's point of view, the colour is the first quality parameter and is even more important as it influences the acceptability or the unacceptability of the product. The appearance of the food, which is one of the most important sensory attribute of the food products, both fresh and processed is in close correlation with the visual appearance and hence the colour of the food. The consumer uses colour as a measure of food quality and associates it with other sensory attributes such as flavor and pigment content [7], [10]. Food visual aspect has a strong influence on consumer's opinion on food quality. Color can be correlated with other quality attributes such as: sensory, nutritional and visual or non-visual defects and helps control the products' quality. Color is a perceptual phenomenon which depends on the observer and on the color observing conditions. L^*, a^*, b^*, hue angle (h^*) and *Chroma* parameters for the samples subjected to the assay analysis were measured [6].

As it can be seen from *Figure 2 a)*, there is an increase for L^* for the stored juices comparing to the fresh ones. A significant increase is found after 2-day storage of samples (**2** and **3**).

Considering that the a^* parameter has positive values for red colors and negative values for green colors and the b^* parameter has positive values for yellowish colors and negative values for bluish colors [8-9], it can be observed from *Figure 2 b)* and *Figure 2 c)* that all samples tend to modify their color (to become brownish). Significant variations are observed in all the studied juices. Analyzing the *Chroma* parameters, *Figure 2 d)* it can be observed a growth for juices stored for 2 days in both the glass bottle (samples **2**), and the PET container (samples **3**), and then a decrease after a storage for 5 days (samples **4** and **5**). Hue (h^*) attribute, *Figure 2 e)* presents negative values, which is consistent with the parameters a^* and b^* which indicate that the changes are perceptible by the human eye, and thus accepts the consumer to consume the product or not.

In *Figure 2 f)* it can be seen ΔE^* for all the juice samples that represent the color difference magnitude between the value of the initial color and the value of the final color.

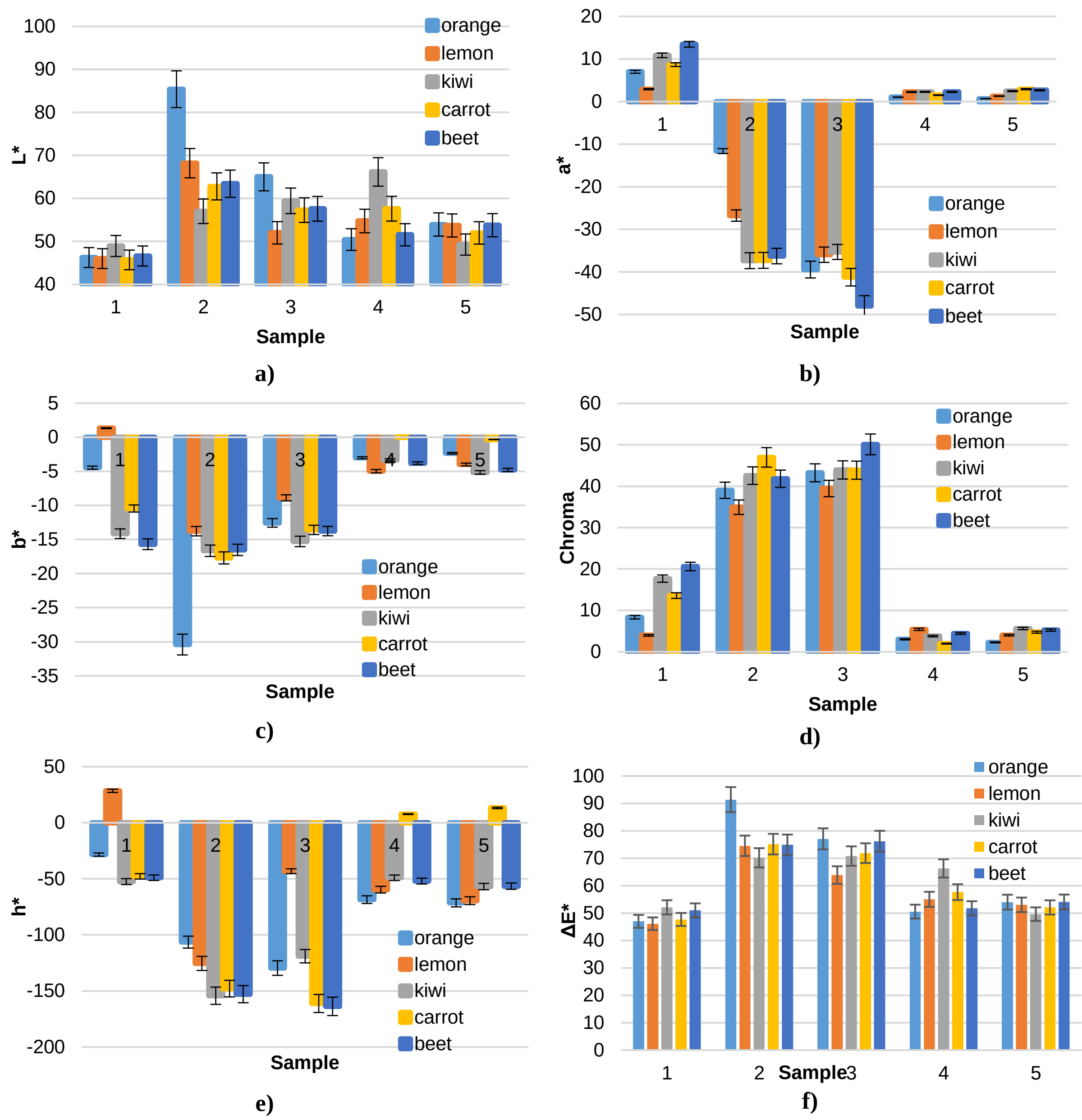

Figure 2. The variation in color parameters for the analyzed samples: a) L^*, b) a^*, c) b^*, d) chroma, e) hue angle, f) ΔE^*

Due to storage without preservatives biochemical changes occur that causes changes in the color and in the other physical parameters, regardless of the storage containers.

4. Conclusion

This paper presents an experimental study on the change of density, electrical conductivity, pH, refractive index, and on the parameters specific to the color of natural juices stored at a temperature of $+4^0$C and normal atmospheric pressure in two types of containers. From the analysis of experimental results, it results that there is an increase in density, in all samples, while the pH changes only slightly in orange juice. Storage temperatures of +4ºC reduce the risk of contamination and decrease the speed of biochemical changes, but this fcat is not sufficient to guarantee the nutritive and organoleptic qualities of the juice and its acceptability by the consumer.

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