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QUALITY ASSESSMENT OF SOME COMMERCIAL ROMANIAN JUICES

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Abstract. The present study consists in a comparative evaluation of the quality of some commercial Romanian juices. The concentrations of metals were compared with the limits imposed by USEPA and WHO. The juices were also investigated from the point of view of stable isotope composition and vitamin C (L-ascorbic acid) content. The isotopic oxygen and hydrogen measurements of investigated juices revealed the fact that from four juices labeled to be "single strength juices", only two samples have isotopic values corresponding to authentic juices and the other two were obtained from concentrated by redilution with water.

Key words: food safety, heavy metals, stable isotope, vitamin C, food control.

1. INTRODUCTION

Food quality is one of the most important factors determining the consumer's perception and acceptance, attraction to, and purchase of the product. Fruit juices are a highly appreciated, tasty food, and usually have exceptional nutritional qualities. However, they can be a potential source of toxic elements, some of them having an accumulative effect or leading to nutritional problems due to the low concentrations of essential elements, justifying the control of mineral composition in juice [1, 2].

Vitamin C (ascorbic acid), an essential vitamin for human nutrition supplied from fruits and vegetables, is a powerful antioxidant involved in the fight against free-radical induced diseases. L-Ascorbic acid (AA) is the main biologically active form of vitamin C [3].

Determination of $\delta^{18}O$ and $\delta^{2}H$ values of water from fruit juices is today applied in routine analysis as an automated and acknowledged method in order to differentiate between directly pressed and rediluted single-strength juices. Moreover, $^{13}C/^{12}C$ proved to be a good tool for characterizing geographical origin. Indeed, the $\delta^{13}C$ values of plant compounds are influenced by the availability of water, relative humidity, and temperature, which control stomata aperture and the internal CO_2 concentration in the leaf [4]. In food sciences, $^{13}C/^{12}C$ ratio is a good probe for detecting the addition of cane sugar or maize glucose syrup to fruit juices [5, 6] and also to distinguish the type of plants that was used in the obtainment of a certain product. Based on the different photosynthetic metabolism of CO_2 plants are spitted in three categories: C_3 (most of the plants including beet sugar), C_4 (*e.g.* sugar cane, corn) and CAM (*e.g.* pineapple, cactus); each of these categories being characterized by different rages of variations of $\delta^{13}C$ values.

The aim of the present work was performed to evaluate the quality of some commercial Romanian juices. H, C, O stable isotope ratios, the content of mineral and toxic metals and vitamin C (L-ascorbic acid) content are presented and discussed in this study.

2. EXPERIMENTAL PROCEDURES

The juice samples were acquired in supermarkets from Romania. They are prepared from fruits such as plums, berries, cranberries, blueberries, mango, pomegranates, cherries, exotic fruits, limes, carrots, apricots, apples and peaches, and vegetables such as potatoes (Table 1). These fruits and vegetables are important food supplements due to their high quantity of water, carbohydrates, vitamins and minerals.

Table 1

Description of juice samples accordingly their labels

Sample Code	Fruit type	Observations
S1	Plums	Single strength juice
S2	Berries	Minimum fruit content: 30%, sugar
S3	Blueberries	Fruit content: 25%, water, sugar
S4	Blueberries	Minimum fruit content: 25%, water, sugar. Made from fruit juice concentrate.
S5	Blueberries	Single strength juice
S6	Blueberries	Recovered from concentrate, sugar
S7	Lemon-lime	Fruit content: 25%, water, mixed fruit juice made from mixed fruit juice concentrate (orange, lemon 7%, lime 3 %, sugar, orange pulp)
S8	Mango	Minimum fruit content: 25%, no sugar added, only contains the sugar from the fruit itself.
S9	Exotic	Juice content: 100 %, mixed fruit juice made from mixed fruit juice concentrate (pineapple, orange, passion fruit, lime, lemon, banana, mandarin, mango, papaya and kiwi). No sugar added.
S10	Tomato	Juice content: 100 %, from tomato juice concentrate. No sugar added.

Table 1

(continued)

S11	Red fruits	Juice content: 100 %, mixed fruit juice made from mixed fruit juice concentrate (apple, grape, black currant, cherry, raspberry, blackberry, elderberry, blueberry, pomegranate and cranberry). No sugar added.
S12	Cherry	Single strength juice
S13	Pomegranates	Recovered from concentrate, sugar
S14	Carrots, apricots, apples	Carrots and apricots pulp. No sugar added.
S15	Carrots, peaches, apples	Carrots, peaches, apples pulp. No sugar added.

2.1. THE MINERAL AND TOXIC METAL CONTENTS DETERMINATION

2.1.1. Sample Preparation

In this study, 2.5 ml of the sample was transferred to Teflon receptacle and after the addition of 2.5 ml of ultrapure nitric acid. Six such receptacles were inserted in a device made of six stainless steel cylinders mounted between two flanges, to confer pressure resistance. The whole system was put in an oven at 180^{o}C for 12 hours. A colorless solution resulted, and ultrapure water was added up to 50 ml. Thus, the juice samples were diluted 1:20 v/v. For each sample analysis three replicates were measured in order to assure the control quality of our measurements.

2.1.2. Apparatus, reagents and materials

Inductively Coupled Plasma Mass Spectrometry (ICP-MS) was used to determine the mineral and toxic metal contents in the commercial juices with A Perkin Elmer ELAN DRC (e) equipped with a Meinhard nebulizer and silica cyclonic spray chamber and continuous nebulization. The operating conditions for Perkin Elmer ELAN DRC (e) were: nebulizer Gas flow rates: 0.92 L/min, auxiliary Gas Flow: 1.2 L/min, plasma Gas Flow: 15 L/min, lens Voltage: 10.50V, ICP RF Power: 1100W, CeO/Ce = 0.023, Ba^{++}/Ba^{+}= 0.021.

Ultra-pure de-ionized water (18 M Ω cm^{-1}) from a Milli-Q analytical reagent-grade water purification system (Millipore), and ultra-pure HNO_3 60% (Lot-No B0157318 MERK) were used. Calibration standard solutions and internal standards were prepared by successive dilution of a multielement ICP-MS calibration std. 3 (Perkin Elmer Lot 30-157AS).

All plastic labware used for the sampling and sample treatment were new or cleaned by soaking 24 h firstly in 10 % HNO_3 then in ultra-pure water.

2.2. STABLE ISOTOPE ANALYSIS

For oxygen-18 determination 5 ml of raw juice (neither centrifuged nor filtered) was equilibrated with CO_2 for 15 hours according to the CEN:ENV 13141:1997 method at 25±0.1°C. The carbon dioxide was then extracted and purified. The ^{18}O isotopic content of the water samples were then analyzed using a stable isotope ratio mass spectrometer IRMS (Delta V Advantage, Thermo Scientific). For the hydrogen analysis a distiller under static vaccum was used with „Rittenberg trousers" on 2-3 ml of fruit juice, always with the quantitative recovery of the water. For δ^2H the equipment used was a Liquid-Water Isotope Analyzer (DLT-100, Los Gatos Research). The isotopic values were calibrated against laboratory-used standards (working standard 1, with $\delta^{18}O = -11.54 \pm 0.1$‰ and $\delta^2H = -79.0 \pm 0.1$‰; working standard 2, with $\delta^{18}O = -7.14 \pm 0.1$‰ and $\delta^2H = -43.6 \pm 1$‰; working standard 3, with δ18O = −2.96 ± 0.1‰ and $\delta^2H = -9.8\pm \pm 1$‰).

The measurements of $\delta^{13}C$ from fruit juices were carried out on an Elemental Analyser (Flash EA1112 HT, Thermo Scientific), coupled with an isotope ratio mass-spectrometer IRMS (Delta V Advantage, Thermo Scientific). For the quality control of our analysis, three working standards were analyzed at the beginning of each sequence, than three replicas from each sample were measured. NBS-22 oil with a certified value of −30.03‰ versus PDB (Pee Dee Belemnite) was used as standard.

2.3. DETERMINATION OF VITAMIN C CONTENT

L(+) – ascorbic acid was purchased from J.T. Baker (Holland), potassium phosphate, acetic acid and methanol of HPLC grade were purchased from Merck (Germany). All chemicals were analytical reagent grade.

The analyses were carried out on a Shimadzu HPLC model LC-2010 (Kyoto, Japan) with DAD detector. The chromatographic separation of ascorbic acid was carried out on LiChrosorb RP-18 column (5µm, 25×0.4 cm, Merck, Germany) thermostated at 30°C with a gradient elution. The eluents consisted of phosphate buffer (pH = 2.7) (A) and methanol (B). The program of gradient elution started from 10 to 20% B in 5 min and then the eluent B decreased in 15 min to 10%. The injection volume of standard and sample was 10 µL and mobile phase was pumped at a flow rate of 0.4 mL min^{-1}.

Triple analyses were performed for each sample. The identification of ascorbic acid was established by comparing the retention time and UV spectra of the peak from juices with the reference standard. The peaks corresponding to the ascorbic acid showed maximum absorption at 243 nm.

3. RESULTS AND DISCUSSIONS

3.1. INDUCTIVELY COUPLED PLASMA MASS SPECTROMETRY (ICP-MS) ANALYSIS

Macro-elements (Na, Mg, P, K and Ca) concentrations of juice samples are presented in Table 2. The SD of measurement samples was: 0.27 for Na, 0.21 for Mg, 0.47 for P, 3.07 for K, 0.55 for Ca, respectively.

Table 2

Macro-element contents of juices (mg/L)

Fruit type	Na	Mg	P	K	Ca
Plums	7.91	46.54	66.85	403.61	37.00
Berries	53.15	25.27	29.17	96.33	20.70
Blueberries	9.65	21.73	17.12	108.36	12.36
Blueberries	28.20	27.77	35.57	217.62	50.60
Blueberries	152.95	62.47	74.19	473.53	69.72
Blueberries	153.86	28.01	30.38	202.87	31.52
Lemon-lime	5.08	23.40	29.92	146.43	17.41
Mango	51.97	29.02	27.29	141.68	20.98
Exotic	70.68	96.70	90.85	585.81	49.89
Tomato	1324.98	92.89	128.47	824.82	73.29
Red fruits	16.58	57.75	62.52	397.85	59.87
Cherry	193.81	142.16	121.82	756.90	107.40
Pomegranates	132.71	13.80	23.40	207.45	0.42
Carrots, apricots, apples	64.22	20.03	24.47	163.37	17.77
Carrots, peaches, apples	74.37	23.25	31.08	178.44	22.64

Recommended daily intake for Na, Mg, P, K and Ca is 2400 mg, 350 mg, 1000 mg, 3500 mg, 1000 mg, respectively [7].

The potassium and sodium are macro-elements required for the maintenance of cellular water balance, acid-base balance and nerve transmission and are required in large amounts in the body [8].

In the present study, the level of sodium and potassium in juices ranged from 5.08 mg/L (Lemon-lime juice) to 1324.98 mg/L (Tomato juice) and 96.33 mg/L (Berries juice) to 824.82 mg/L (Tomato juice), respectively. The highest content of sodium and potassium was in sample of tomato.

Calcium is found mainly in our bones and teeth. Calcium also regulates cell membrane permeability to control nerve impulse transmission and muscle contraction. It is important for blood clotting, and it regulates hormonal secretion and cell division [9]. Calcium, though an important dietary component for most, can be an issue for patients with renal insufficiency [10]. The calcium contents of the analyzed juices ranged from 0.42 mg/L (Pomegranates juice) to 107.40 mg/L (Cherry juice). Increased presence of calcium in fruit juices may occur as a result of using acidity regulators during the production process, *e.g.* calcium ascorbate or calcium chloride. These substances are used to prevent enzymatic browning or to enrich the products in vitamin C, to prevent changes in the smell if juices and as antioxidants and acidity regulators [11, 12].

Magnesium is required over 500 enzymes that regulate sugar metabolism, energy production, cell membrane permeability, and muscle and nerve conduction [9]. The highest content of magnesium was determined in Cherry juice (142.16 mg/L), whereas its lowest presence was noted in Pomegranates juice (13.80 mg/L). Mg concentration is highest probably due to the fact that magnesium sulphate is usually added to juices as preservatives.

Phosphorus is required for energy production, DNA synthesis and protein synthesis. It is also needed for calcium metabolism, muscle contraction and cell membrane [9].

The phosphorus contents observed in the present study for the fruit juices ranged from 17.12 mg/L (Blueberries juice) to 128.47 mg/L (Tomato juice).

The mineral and toxic metal concentrations of samples are presented in Table 3.

The SD of measurement samples was 0.51, 3.62, 2.59, 0.05, 0.25, 0.86, 3.35, 0.07, 0.03 and 0.10 for Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Cd, Pb, respectively.

The essential elements, like copper, zinc and iron are very important because they are involved in many enzymes systems in the human body, but high concentrations are toxic [13].

Copper is an essential element for human beings but a Recommended Dietary Allowance has not yet been established. A safe and adequate range of intake was established the range for copper, 2 to 3 mg/day [14]. As little as 10 mg of copper can have a toxic effect [7]. However, when present in some beverages such as fruit juices, it tends to impair shelf life and keeping quality of juices, so it is expected that fruit juice should contain low levels of copper [15].

The concentration of cooper in juices was highest in tomato juice (609.98 μg/L) and was lowest in berries juice (16.26 μg/L). Though zinc is most often used as part of a multivitamin/mineral formula, active individuals, especially athletes, have become interested in zinc because of its important role in testosterone production. The daily value for Zn is 15 mg [16]. The zinc content of the analyzed juices ranged from 112.62 μg/L (pomegranate juices) to 907.42 μg/L (tomato juice). Iron is required for energy and endurance because it delivers oxygen throughout the body. But it is necessary only in small amounts for optimal health. Between 10 and 18 mg taken daily has been shown to be effective [17]. The highest content of iron was revealed in tomato juice (231.44 μg/L). The lowest amount of this metal in juices occurred in pomegranates juice (60.30 μg/L). The content of iron in juices depends on the percentage composition of raw materials. The literature studies stated that the presence of calcium reduces the absorption of iron, whereas the presence of copper increases its absorption [18, 19]. Iron absorption is also stimulated by ascorbated acid [20].

Table 3

Mineral and toxic metals contents (μg/L) of juices and maximum admissible limit by different international organizations (USEPA, WHO)

Fruit type	Cr	Mn	Fe	Co	Ni	Cu	Zn	As	Cd	Pb
Plums	26.37	459.78	214.18	0.60	43.56	86.98	382.00	2.28	< DL	2.80
Berries	13.45	183.90	211.69	<DL	10.76	16.26	161.48	0.94	< DL	3.40
Blueberries	5.97	2240.12	63.88	< DL	1.52	18.72	136.56	0.58	< DL	2.62
Blueberries	5.82	614.96	132.10	0.34	15.82	21.60	285.74	3.78	< DL	11.86
Blueberries	11.65	1179.02	148.65	1.82	103.56	53.44	213.80	0.76	0.66	6.74
Blueberries	7.54	422.18	85.80	0.28	105.90	25.26	290.50	< DL	1.78	3.76
Lemon-lime	7.18	108.40	99.84	< DL	105.62	81.82	245.60	< DL	< DL	4.38
Mango	10.28	246.68	80.26	0.76	155.56	151.88	244.80	0.94	0.54	3.72
Exotic	5.27	6440.02	114.63	3.04	42.84	124.04	161.76	3.02	0.34	1.30
Tomato	14.24	469.62	231.44	4.94	321.40	609.98	907.42	3.22	7.94	5.44
Red fruits	6.76	780.56	141.93	1.04	5.44	228.94	280.24	2.46	0.26	11.06
Cherry	6.43	538.74	129.27	0.88	65.52	49.32	261.98	0.20	< DL	1.78
Pomegranate	8.20	122.72	60.30	< DL	9.10	112.06	112.62	1.14	< DL	1.66
Carrots, apricots, apples	3.07	113.56	80.92	0.70	9.68	214.30	419.80	0.30	2.06	31.64
Carrots, peaches, apples	4.85	155.64	126.93	1.62	51.4	419.08	456.12	0.32	3.82	33.62
USEPA[(a)]	100	50	300	100	100	1300	5000	10	5	15
WHO[(b)]	50	400	[3]NGL	[1]NM	70	2000	[2]NGL	10	3	10

[1]NM-not mentioned
[2]NGL-no Guideline, because it occurs in drinking water at concentrations well below those at which toxic effects may occur
[3]NGL-no Guideline, because it is not of health concern at concentrations normally observed in drinking water, but may affect the acceptability of water at concentration above 300 μg/L
DL-0.001 μg/L
Source:(a)http://www.cdph.ca.gov/certlic/drinkingwater/Documents/DWdocuments/EPAandCDPH-11-28-2008.pdf;
(b)-WHO, 2008

Manganese plays a number of essential roles in cellular function and human metabolism. Manganese can function both as a constituent of metallo enzymes and as an enzyme activator. It is also now known that manganese activated enzymes are involved in the synthesis of proteoglycan molecules, which add structural integrity to bone and joint cartilage [21]. Recommended daily intake for Mn is 5 mg. Excess manganese may hinder iron adsorption [7]. Manganese contents ranged at the levels between 108.40 μg/L(lemon-lime juice) and 6440.02 μg/L (exotic juice).

Also, high concentrations of manganese were obtained in blueberries, red fruits juice (2240.12 μg/L, 1179.02 μg/L, 780 μg/L).

Cobalt is of interest to nutritionists because it is an essential part of vitamin B_{12} (cyanocobalamin) [22]. The cobalt content was ranged from 0.28 μg/L (blueberries juice) to 4.94 (tomato juice). For some juice samples, the cobalt concentration was below the detection limit (0.001 μg/L).

Recommended daily intake for Cr and Ni is 120 μg, < 1 mg, respectively. Doses larger than 200 μg (for Cr) are toxic and may cause concentration problems and fainting. Products containing nickel may cause skin rash in case of allergies [7]. The concentration obtained for these metals in fruit juices was ranged from 3.07 μg/L to 26.37 μg/L (Cr) and from 1.52 μg/L to 321.40 μg/L (Ni).

The toxic metals include lead, cadmium, arsenic and others. These often function in enzymes to some extent, but not nearly as well as the physiological mineral. All toxic metals are neurotoxic. They contribute to hundreds of health conditions [7].

The concentration obtained for toxic metals in juices sample was ranged from 0.20 μg/L to 3.78 μg/L (As), from 0.26 μg/L to 3.82 μg/L (Cd), from 1.30 μg/L to 33.62 μg/L (Pb). Also, As and Cd contents of some juices were found lower detection limit.

On comparison of the levels of heavy metals in some commercial fruit juices with standards set by the US Environmental Protection Agency (USEPA) [23], World Health Organization (WHO) [24], as shown in Table 2, the concentrations of Cr, Fe, Co, Cu, Zn and As was below the limit imposed by USEPA and WHO. For five samples (blueberries, mango, tomato lemon-lime juice), the Ni concentration was above its limit. In two samples (tomato and Carrots, peaches, apples juice), the Cd concentration surpassed the WHO limit. In the case of Pb concentration, four samples (blueberries, red fruits, Carrots, apricots, apples and carrots, peaches, apples juice) exceed the limit imposed by WHO and two samples (carrots, apricots, apples and carrots, peaches, apples juice) surpassed maximum admissible limit by USEPA. For the majority of analyzed samples, the concentration of Mn exceeded the limits imposed by WHO and USEPA safety standards.

Generally, in this study the concentrations obtained for various metals are comparable with the published results of different authors [2, 25–31]. The major or minor differences of heavy metals in commercial fruit juices may be due to fruit varieties, localities and processing factors. Piping and containers used by the factory for processing and storage can also increase the metal content in the juice.

3.2. STABLE ISOTOPE ANALYSIS

Determination of $\delta^{18}O$ and $\delta^{2}H$ values of water from fruit juices is today applied in routine analysis as an automated and acknowledged method in order to differentiate between directly pressed and rediluted single strength juices. Authentic juices have elevated $\delta^{18}O$ and $\delta^{2}H$ content of water as compared to water from rediluted products made using tap water which is relatively depleted in heavy oxygen and hydrogen isotopes [32]. On the other hand, the stable carbon isotope ratio has been widely used to trace the presence of sugar obtained from C_4 plants in beverages that are traditionally made from C_3 plants [33]. This detection is based on the fact that the stable carbon isotope ratios (expressed as $\delta^{13}C$) of C_3 and C_4 plants are different, with ranges of –11 to –14‰ for C_4 plants and those of C_3 plants varying between –24 to –32‰ [34–36]. In the C_3 plants category is included most of the fruits while the C_4 plants category contains the plants which produce the most inexpensive sugars available on the market, like maize [37, 38]. The third category of plants, accordingly to this classification are the CAM plants having the range of variations of $\delta^{13}C$ value between –10 to –20‰.

In Table 4, the isotopic values ($\delta^{18}O$, $\delta^{2}H$ and $\delta^{13}C$) of investigated commercial juices are presented. Also, the mean isotope values of Cluj-Napoca tap water is shown in Table 4. Stable isotope ratio measurements of oxygen and hydrogen from fruit juices water could differentiate between the directly press juices from those obtained from concentrates. The common practice of fruit juices producing is to concentrate pressed juices for easier and cheaper storage and then dilute with tap water just before packaging [39].

Table 4

The isotopic values ($\delta^{18}O$, $\delta^{2}H$ and $\delta^{13}C$) of investigated commercial juices

Sample code	Fruit type	$\delta^{13}C$[‰] ± 0.2	$\delta^{2}H$[‰] ± 0.6	$\delta^{18}O$[‰] ± 0.2
S 1	Plums	–26.3	–39.4	–0.4
S 2	Berries	–24.0	–88.4	–12.4
S 3	Blueberries	–28.5	–70.7	–9.7
S 4	Blueberries	–26.4	–79.5	–9.8
S 5	Blueberries	–24.7	–76.8	–9.6
S 6	Blueberries	–25.2	–81.7	–10.9
S 7	Lemon-lime	–27.6	–68.7	–9.2
S 8	Mango	–28.4	–37.1	–1.4
S 9	Exotic	–17.7	–80.0	–11.1
S 10	Tomato	–27.4	–51.7	–7.0
S 11	Red fruits	–25.7	–52.6	–6.8
S 12	Cherry	–26.4	–67.4	–7.9
S 13	Pomegranates	–26.4	–81.4	–11.0
S 14	Carrots, apricots, apples	–26.6	–68.4	–7.4
S 15	Carrots, peaches, apples	–27.6	–62.9	–6.5

For investigated samples, on the bases of our previously reported results [40–42] and also on those from literature [39] we can state that, except the samples S1 and S8, all samples were reconstituted from concentrates by re-dilution with tap water. It can be seen that apart the isotopic values of samples S1 and S8, which correspond to single strength juices, the rest of the samples are characterized by isotopic values closer to those corresponding to tap water as compared with samples S1 and S8. Despite the fact that fruit juices S5 and S12 were labelled to be "single strength juices", the isotopic values of oxygen and hydrogen indicated us that these two samples were reconstructed from concentrates by redilution with water. Except the $\delta^{13}C$ value corresponding to sample S9, the isotopic ratios of carbon ($^{13}C/^{12}C$) indicate only the presence of C_3 plants, as row materials, in the manufacture process of fruit juices. The isotopic value $\delta^{13}C= -17.7‰$, obtained for sample S9 is explain by the presence as the main ingredient of pineapple juice which is a CAM plant, having a higher isotopic value as compared with C_3 plants.

3.3. VITAMIN C (L-ASCORBIC ACID) ANALYSIS

Vitamin C, also known as ascorbic acid, L-ascorbic acid or L-ascorbate is an essential vitamin for human nutrition. Besides its role to prevent scurvy, many other health benefits have been attributed to ascorbic acid such as antioxidant, anti-carcinogenic, immunomodulator and cold prevention [43].

In our study, the HPLC-DAD method was used for identification and quantification of the ascorbic acid in some commercial juices.

The ascorbic acid was quantified by the method of external standard. The calibration curve of ascorbic acid was established by injecting 10 μL of six ascorbic acid solutions in the concentration range 0.01–0.15 mg/mL, prepared from a 1 mg/mL ascorbic acid stock solution by successive dilutions with ultrapure water. The injection of each sample into HPLC system was performed thrice. Calibration curve was plotted as ascorbic acid peak area *versus* concentration. The regression equation of the calibration curve and the coefficient of determination (R^2) were: $y = 3.862e^7x + 1.1083e^5$ and $R^2 = 0.9992$, respectively. The limit of detection (3.39 ng/mL) and the limit of quantification (6.67 ng/mL) were calculated.

The highest ascorbic acid concentration was found in tomato juice (S10) (7.22 mg/dL), while blueberries juice (S3) and lemon-lime juice (S7) contained the lowest concentrations of ascorbic acid (0.12 mg/dL and 0.16 mg/dL, respectively). The explanations for the variance in concentrations include the processing of the juices and the concentration of these (the tomato juice contains 100% juice, without other additives and it was obtained from tomato juice concentrate, while blueberries (S3) and lemon-lime (S7) juices contain only 25% fruit content).

After the analysis it was found that the amount of ascorbic acid is higher in the single strength juices (S1, S5, S10 and S12), followed by the juices obtained from mixed fruit juice, recovered from concentrate, the lowest quantity being found in very diluted juices (S3 and S7). In the case of juices obtained from blueberries it was found that the highest quantity of ascorbic acid was obtained in single strength juice (S5), followed by juice obtained from fruit concentrate (S4), juice recovered from concentrate (S6) and diluted juice (S3).

Our results were compared with the existing literature data on the ascorbic acid content of some fruit juices. Consequently, the quantities of ascorbic acid found in our juice samples was in some cases higher than those found in the literature (mango juice), approximately the same (plum juice) or in much smaller quantity (red cherries juice, pomegranate juice, lemon juice) [44].

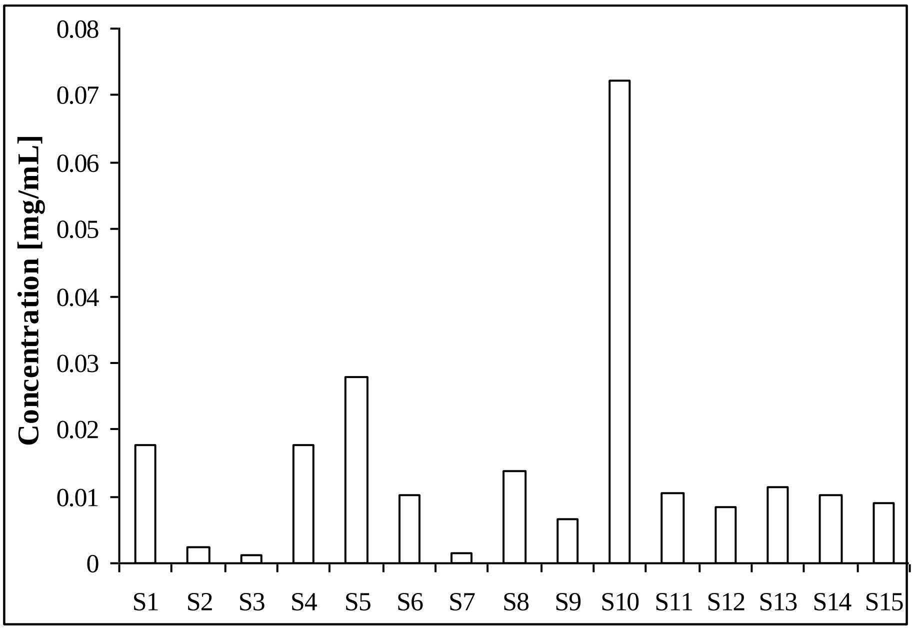

Fig. 1 – Ascorbic acid concentration of investigated commercial juices.

4. CONCLUSIONS

The results of this study indicate that the commercial juices studied are well provided with essential nutrients required for humans. The highest concentrations of essential element were found in tomato juice. The mineral and toxic metals contents of juices were compared with maximum admissible limit by different international organizations, such as USEPA, WHO, so we registered exceeded for some metals (Ni, Cd, Pb, Mn, respectively) or normal values for Fe, Cu, Zn, Co, Cr, As, respectively. The highest concentrations of manganese in S3, S5, S9 juices was most probably caused by the presence blueberries, pineapple and bananas fruits rich in manganese an ingredient of the juices.

The isotopic oxygen and hydrogen ($\delta^{18}O$, $\delta^{2}H$) measurements of investigated commercial juices revealed the fact that from four juices labeled to be "single strength juices" , only the samples S1 and S8 have isotopic values corresponding to authentic juices, the other two (S5 and S12) were obtained from concentrated by redilution with water. The presence of pineapple juice as main ingredient for the S9 juice, was highlighted by the $\delta^{13}C = -17.7‰$ value, which indicated the use of CAM fruit (pineapple) in the manufacture process of this juice. This also is consistent with the information provided on the juice label.

The HPLC quantification of the ascorbic acid from the studied commercial juices presented the highest values in the single strength juices. The tomato juice had the maximum value for ascorbic acid content (7.22 mg/dL). The amount of ascorbic acid decreased in the juices where the amount of added water and sugar increased.

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