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# Physico-chemical and sensory quality of pasteurized apple juices extracted by blender and cold pressing juicer

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**Abstract**. Worldwide, one of the most consumed fruit juices is apple juice, preferred by both adults and children due to its authentic taste, but also due to its nutritional and health benefits. Apple juice contains sugars, malic acid, soluble pectin, vitamin C, phytochemicals and minerals. The production process influences the juice composition. There is a growing market for natural cloudy apple juice, even though fruit juice is mostly consumed as clear juice. The aim of this study was to obtain cloudy apple juice by using a blender and a cold pressing juicer for extraction and to evaluate their physico-chemical and sensory qualities. The apple juice samples were obtained from three different apple cultivars: "Gala", "Braeburn" and "Golden Delicious". After extraction, apple juice samples were pasteurized and cooled. In this study, physico-chemical analyzes (like moisture, water activity, pH, titratable acidity, total soluble solids, electrical conductivity, color parameters) were performed immediately after processing and at 7, 14, 21 days of storage at room temperature. The results showed that the investigated parameters of the apple juice samples varied differently depending on both the apple cultivar and the processing method used. Sensory analysis showed that certain types of apples can be suitable for extracting juice using a blender ("Golden Delicious"), while others such as "Gala" apples can be used to obtain juice by cold pressing.

***Keywords*:** apple juice; physico-chemical characteristics; sensory analysis; storage; thermal pasteurization.

## 1. Introduction

Fruit juices are popular because of their nutritional value and health benefits, such as reducing the risk of heart disease and preventing cancer, diabetes, asthma, infections, intestinal disorders, as well as lowering the oxidation of low-density lipoproteins [1, 2]. They contain antioxidants, dietary fibres, vitamins and minerals, and have pleasant taste and aroma [3]. Juices without additives but with a long shelf life are in demand on the market. Thermal treatments such as pasteurization are necessary to preserve juices by inactivating microorganisms and enzymes [4], but higher temperatures affect the nutritional value of the products [5]. Petruzzi *et al.* [6] stated that for fruit juice pasteurization, with inactivation of microorganisms and enzymes, the temperature used can range between 80 and 100 °C. Different time-temperature combinations (70 °C, 80 °C and 90 °C for 10, 20, 30 and 40 min) for star fruit juice pasteurization were investigated by Shourove *et al*. [7], while Hameed *et al.* [4] considered the following time-temperature 65 °C for 15, 25 and 35 min, 75 °C for 10, 20 and 30 min and 85 °C for 5, 10 and 15 min for pasteurization of apple juice. The pH, browning index and color changed with increasing time and temperature, while for the total soluble solids and total polyphenol content no significant changes were observed [7]. Zawawi *et al.* [8] indicated that approximately 80% of polyphenol oxidase enzymes responsible with enzymatic browning are inactivated during thermal processing of food (70 $^{o}$C to 80 $^{o}$C for 5–25 min). Prior to pasteurization, juice is extracted by mashing and pressing the fruit pulp [9]. Fruit juices can be easily produced by consumers at home, using kitchen appliances such as blender or cold press juicer. The nutritional quality of the juice is preserved if, for the extraction process, a cold-pressed juicer is used. This type of juicer has almost no heat generation but is more expensive than centrifugal juicers [10]. The effect of extraction using different types of juicers on the quality of the juice was investigated by Rajasekar *et al.* [11] (blender and mechanical press), Kim *et al.* [12] (blender, low-speed masticating and high-speed centrifugal juicers), Khaksar *et al.* [10] (blender, cold-pressed and normal centrifugal juicers). Rajasekar *et al.* [11] reported blending as the most suitable method for preserving nutritional value of pomegranate juice, Kim *et al.* [12] stated that the low-speed masticating juicer is more suitable for grape juice nutritional content preservation, while Khaksar *et al.* [10] specified that there are no significant differences between bioactive compounds contents and antioxidant capacity of juices (pineapple, guava, carrot, red and white dragon fruits) obtained through cold-pressed and normal conditions. However, they also observed that physico-chemical properties, bioactive compounds and antioxidant capacity were unchanged until day 5 of storage in refrigerator [10].

It is well known that the most appreciated and consumed of all fruit juices are those obtained from oranges and apples, followed by fruit mixture, pineapple, grapefruit, peach, pear, grape, berries and

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others [13-15]. Apple (*Malus domestica*) is one of the most consumed fruits, raw (47.70 g fresh apple/person/day in EU) or processed (e.g. approximately 2.31 L apple juice/person in Europe) [16, 17], with a high sugar content (7.41-14.2%) and a malic acid content ranging from 0.172 g to 2.97 g/100 g, as well as a phenolic content which can be between 0.11 and 0.374 g/100 g [18]. Apple fruits can be processed into juice, vinegar, cider, powders, chips and sweets [18 -20]. According to Zhu *et al.* [21], consumers consider fresh cloudy juice more suitable due to high level of bioactive compounds. Cloudy apple juice which contains pulp particles dispersed in a serum (pectin and proteins) [20, 21] is closer to the whole fruit and in terms of health benefits it seems to be superior to clear apple juice according to Vallée Marcotte *et al.* [2]. Damian *et al.* [20] evaluated the effect of storage at refrigeration temperature on the physical, chemical and rheological properties of cloudy apples juices obtained from "Idared" and "Jonatan" cultivars with a special robot. Hameed *et al.* [4] investigated total soluble solids, ascorbic acid and sugars of apple juices obtained with screw type extractor and stored at refrigeration temperature. Also, pH, titratable acidity, soluble solids and sugar content of apple juices obtained with a hydraulic press were investigated by Riekstina-Dolge *et al.* [22], while Wilczyński *et al.* [23] determined the moisture content, soluble solids content, pH, viscosity, total phenolic content and antioxidant activity of apple juices obtained with basket and screw presses.

Meanwhile, the present study aims to evaluate the effect of storage at room temperature on the physico-chemical parameters of pasteurized cloudy apple juice, without additives, obtained by using a blender and a cold pressing juicer. In addition, sensory and statistical evaluations were carried out.

## 2. Experimental

### *2.1. Materials and reagents*

All chemicals and reagents (sodium hydroxide, NaOH; methanol 99.8%, $CH_3OH$; sulfuric acid 95-98%, $H_2SO_4$; magnesium chloride anhydrous, $MgCl_2$; ferric chloride, $FeCl_3 \cdot 6H_2O$; chloroform, $CHCl_3$) utilized in the analyses in the present study were procured from Sigma-Aldrich.

Fresh, matured and uniform sized apples were purchased from a local market in Suceava, Romania. Three different cultivars, "Gala" (Ga), "Braeburn" (Br) and "Golden Delicious" (Go), were chosen to obtain apple juice samples (Figure 1).

### *2.2. Apple fruit juice preparation*

The fruits were washed with tap water, dried and cut into small pieces. Core and seeds were removed only for the fruits which were blended. Two different juice extraction methods: cold-pressed juicing and blending were used (Figure 1). After extraction, the apple juice was packaged in glass bottles and pasteurized in a water bath at 90 ºC for 25 minutes and cooled to 25 ºC according to Damian *et al.* [20].

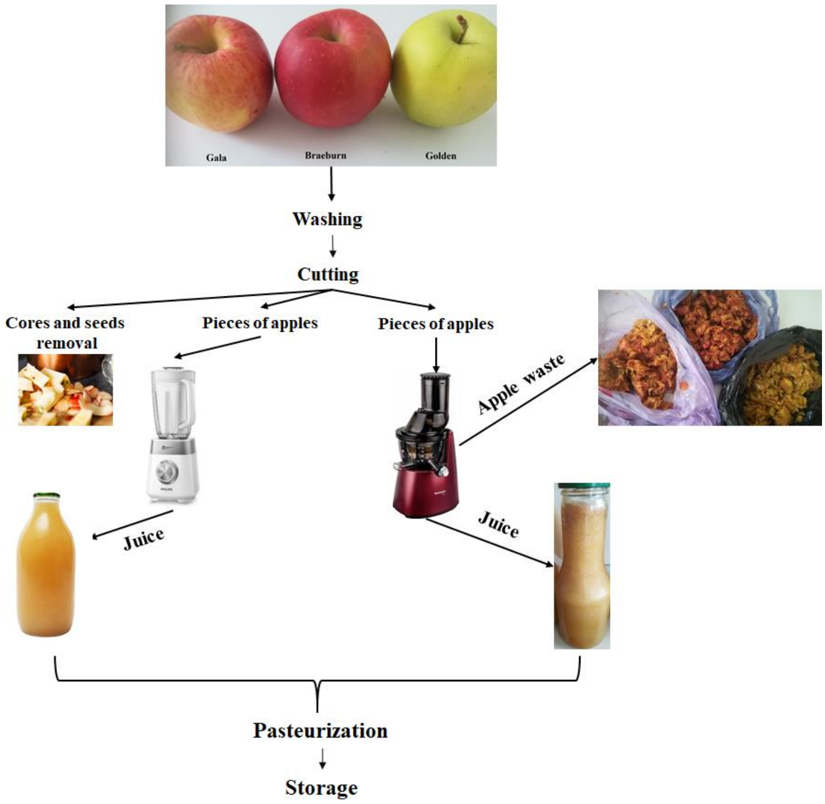


**Figure 1.** Apple juice samples preparation steps

Samples were stored at room temperature, and the analyses were performed immediately after processing and at 7, 14 and 21 days of storage, in order to investigate the temperature and time period effect on the quality of blended and cold-pressed apple juices. It is important to mention that sample bottles were unsealed after pasteurization, stored (as if they had been kept at home by the consumer for 21 days) and investigated. Approximately 1.67 L of apple juice (1.6 L "Gala" cultivar, 1.75 L "Braeburn" cultivar and 1.65 L "Golden Delicious" cultivar) can be obtained by cold pressing 2 kg of fresh apples.

### 2.3. Physico-chemical analysis

*Moisture content* was determined using the method described by Gbarakoro *et al.* [24], thereby 10 mL of apple juice were measured and placed in a cleaned and dried crucible, weighed and dried in an oven at 110 ºC for 3 h until constant weight. Results were calculated based on the equation provided by Ghinea *et al.* [25].

*Water activity* (*aw*) was measured at 25 °C, by using a water activity meter AquaLab Lite, an appropriate volume of apple juice sample was places in a special cuvette and introduced in the *aw* chamber [19].

*Ash content* was determined based on the method presented in AOAC [26], therefore 10 mL of apple juice were measured, they were placed into a dry pre-weighed crucible, and the nutrients and fibers present in the juice were burned at 500 ºC for 3 h until a white ash is obtained.

The *pH* was obtaining by inserting the pH electrode of the Fisher Scientific ACCUMET Bio Set AE150 laboratory pH meter into a volume of 10 mL of apple juice distributed in a beaker after calibration [19, 27, 28].

*Titratable acidity* (TA) was determined by titration of 50 mL dilution (5 mL of apple juice were diluted with distilled water) with 0.1 N NaOH in the presence of phenolphthalein as an indicator. The results are expressed as malic acid (%), which is the predominant organic acid in apple fruit [9, 19, 29]. The calculation of the titratable acidity for each juice sample investigated was performed based on the equation provided by Sadler and Murphy [30].

*Total soluble solids* (TSS) were determined by placing two drops of apple juice on the digital hand-held refractometer lens. The obtained results are reported as "degrees Brix" (°Brix), after values correction to the equivalent reading at 20 °C [19, 31, 32].

*Electrical conductivity* (EC) of juice apple samples was obtained with a laboratory conductometer (VioLab COND 51+ Set) by inserting the electrode into 10 mL of apple juice after calibration. Results were displayed on the conductometer screen and expressed in µS/cm [19, 24, 33].

*Color measurement* was performed by using Konika Minolta CR 400 colorimeter, and the color parameters determined were: L* (light–dark spectrum, from 0 = black to 100 = white), a* (green–red spectrum; −a = green, +a = red), b* (blue–yellow spectrum; −b = blue, +b = yellow). Browning index (BI) was calculated according to the equation presented by Ghinea *et al.* [19].

### 2.4. Sensory evaluation

Sensory analysis is used in food industry to assess the quality of a product with respect to color, aspect, aroma and taste [10]. In this study, the sensory evaluation tests were performed by a panel of 11 experienced engineers from food industry using the nine points of the standard hedonic scale, where 9 denoted "like extremely", 5 "neither like nor dislike", and 1 indicated "dislike extremely" [19, 34]. 50 mL of each juice sample was served to the evaluators at room temperature in plastic containers together with still water [27, 31, 35].

### 2.5. Phytochemical analysis

*Test for flavonoids* (cyanidine test) was performed according to the method of Stankovic [36]: 0.5 mL of each type of juice was mixed with 2 mL of methanol ($CH_3$-OH) and 1 mL of concentrated sulfuric acid ($H_2SO_4$) was added. A spatula was used to add a powder of magnesium chloride ($MgCl_2$) and the mixture observed for 1 min for effervescence.

*The testing of tannins* (ferric chloride test) was performed according to the method of Banso and Adeyemo [37]: 0.5 mL of each type of juice was added to tubes with 20 mL of boiled distilled water and then heated for one hour. Five drops of ferric chloride ($FeCl_3$) solution were added and the tube was left to stand for color development.

*Terpenoid test* (Salkowski test). The method described by Ayoola *et al.* [38] was used to test terpenoids. In different test tubes, to 0.2 mL of chloroform, 0.5 mL of each juice sample was added. Finally, concentrated $H_2SO_4$ (0.3 mL) was carefully added to form a layer.

*Phenol testing*. To 1 mL of each juice sample, a drop of 5% $FeCl_3$ solution was added [27].

### 2.6. Statistical analysis

All experiments were performed in triplicate and the results were further investigated using statistical software (Minitab version 17) from which the following method was selected: an analysis of variance (ANOVA) with a 95% confidence interval ($p < 0.05$) and Tukey Test. Also, the Pearson correlations between the parameters were determined.

## 3. Results and discussion

### 3.1. Moisture, water activity and ash content

Moisture content of apple fruits influences the yield of juice processing [35]. In fresh apple samples, the moisture content was determined as follows: 80.38% for "Golden Delicious" cultivar, 83.95% for "Gala" cultivar and 86.02% for "Braeburn" cultivar. These values are close to those reported by Włodarska *et al.* [35] (84.0 – 85.27%), Ghinea *et al.* [19] (83.97-86.27%) or Mureșan *et al.* [39] (79.06 - 88.06 %). The moisture content of apple juice obtained by cold pressing was between 80.40% ("Gala" cultivar) and 86.37% ("Braeburn" cultivar), while for apple juice samples obtained from the cultivar "Golden Delicious" moisture content was 81.04%. It was observed that for the juice samples obtained by blending, the values of the moisture content were higher than those obtained for the samples by cold pressing, thus was obtained a moisture content of 84.60% for apple juice from "Golden Delicious" cultivar and 87.77% for apple juice from "Gala" cultivar. The moisture content for juice samples obtained from "Braeburn" cultivar was 85.36%. These values are close to those reported in the literature, for example Okokon and Okokon [3] determined a moisture content of 87.73% for fresh apple juice. Water activity is a better indication of food perishability than water content [40]. Figure 2 shows the results obtained after water activity evaluation of apple juice samples during storage under ambient conditions. The *aw* values of fresh apple juices varied from 0.893 (Ga2 - apple juice samples obtained by cold pressing of "Gala" apples) cultivar to 0.920 (Go1- apple juice samples obtained by blending of "Golden Delicious" apples) (Figure 2).

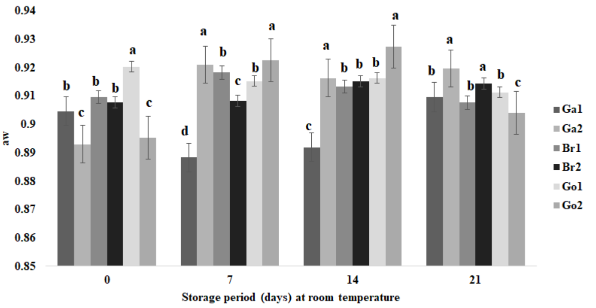


**Figure 2.** Water activity (*aw*) evaluation of apple juice samples during storage under ambient conditions (Ga-apples from the "Gala" cultivar, Br-apples from the "Braeburn" cultivar and Go - apples from the "Golden Delicious" cultivar; apple juice samples obtained with 1- blender and 2 - cold pressing juicer). Different lowercase letters (a–c) show significant differences between the groups ($p < 0.05$)

These values are slightly lower than those reported by Siguemoto [41]: the water activity of cloudy apple juice varied between 0.987 and 0.994 (0.990 for "Royal Gala" juice and 0.991 for "Red Delicious" juice). During storage of apple juice at room temperature, the *aw* values vary depending on the apple cultivar and how it is obtained, and after 21 days of storage the *aw* values exceed 0.900 for all samples, ranging from 0.904 to 0.919. Analyzing statistically the data obtained, it was observed that the *aw* values for the juice samples from the "Gala" and "Braeburn" cultivars (Ga2, Br2) obtained by cold pressing are statistically different from the values obtained for the juice samples obtained with the help of the blender (Ga1, Br1 and Go1).

The ash content in the juice samples obtained in the blender was 0.15% Br1, 0.18% Ga1, 0.34% Go1, while for the juice samples obtained by cold pressing the following values were determined 0.13% Ga2 and Go2, 0.42 % Br2.

### *3.2. pH, titratable acidity and total solid content*

An important parameter of apple juices, easily to measure, is acidity. It is considered for fresh juices that if the acidity is too low, the juice will be lacking in freshness. Apple cultivar, harvest time and apple juice processing method are the main parameters that influence the pH value of juices [28]. Giryn *et al.* [42] reported that the pH value of raw juices varied between 3.39 and 3.77, the same values were presented by Nadulski *et al.* [43], while Karaman *et al.* [44] obtained for apple juices inoculated with yeast values between 3.34 and 3.68. Siguemoto [41] reported for cloudy apple juices pH values between 3.25 and 3.97. The pH of majority apple juices found on the market varies from 3.0 (more acidic juices) to 4.5 (juices with very little acidity) [45].

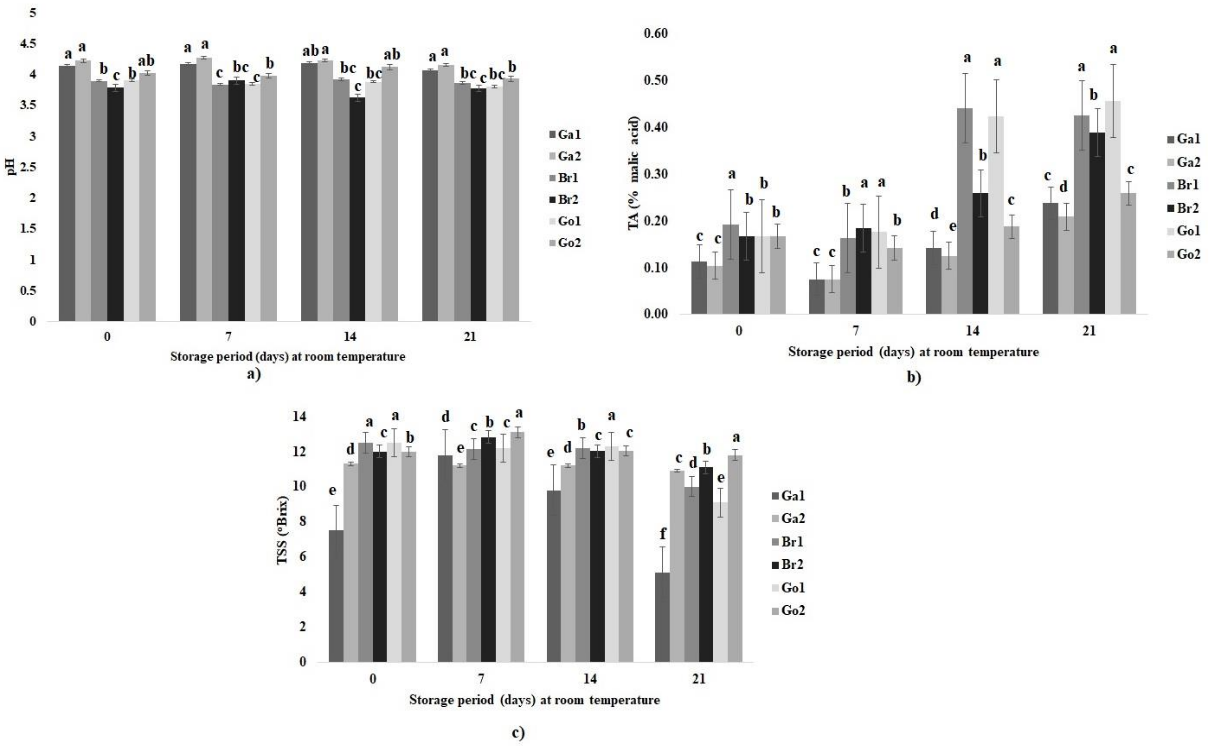


**Figure 3.** pH, Titratable Acidity (TA) and Total Soluble Solids (TSS) evaluation of apple juice samples stored under ambient conditions (Ga-apples from the "Gala" cultivar, Br-apples from the "Braeburn" cultivar and Go - apples from the "Golden Delicious" cultivar; apple juice samples obtained with 1- blender and 2 - cold pressing juicer). Different lowercase letters (a–f) show significant differences between the groups ($p < 0.05$)

From Figure 3a it can be seen that the average pH values obtained for all types of apple juice investigated in this study fall within these limits. It can be seen that the pH of the apple juice obtained from the "Gala" cultivar with the help of the blender is over 4, varying in time between 4.07 and 4.18 (storage at 23 ℃). For the other types of juices investigated, the pH values are below 4, but not lower than 3.80 (Figure 3a). It was observed that the pH values decrease slightly for the samples stored at 23 ℃, which means that over time the juice samples become more acidic.

Titratable acidity measures the total concentration of acid (citric, malic, lactic, tartaric and acetic) in a food. Organic acids present in juices influence flavor, color, microbial stability and preservation of quality. The predominant acid in apples is malic acid, with a content between 0.27 and 1.02% acid according to Sadler and Murphy [30]. Siguemoto [41] obtained for cloudy apple juices TA values ranging from 0.17 to 0.59% malic acid. The values obtained in this study for the samples of fresh pasteurized apple juice are between 0.10 (Ga2) and 0.19% (Br1) malic acid according to Figure 3b, these varying in time until the 21st day when they increased, being between 0.20 (Ga2) and 0.46% (Go1) malic acid. TA increased over time, mostly for the blender juices obtained from the Go and Br apple varieties, and the least for the juices obtained by cold pressing from the Ga and Go apple varieties.

Total soluble solids content determined in this study are illustrated in Figure 3c.

The TSS values of fresh pasteurized juices varied from 7.5 to 12.5 ° Brix. Kowalczyk [46] reported that TSS content of apple juice extracted in Polish industry is ranged from 11.0 to 12.4 ° Brix, while Eisele and Drake [47] found that TSS content of apple juices varies from 10.26 to 21.62 ° Brix, depending on the cultivar. TSS values reported by Siguemoto [41] for cloudy apple juices were between 12 and 14 ° Brix. Serpen [48] indicated that the sugar content in juices obtained from fresh fruit was about 13 ° Brix. A high Brix value (20 or more) is associated with more concentrated juice, while a low Brix value indicates a lower concentration level [49]. According to European Union standards, the minimum levels of extract for reconstituted fruit juice and reconstituted fruit puree is 11.2 ° Brix [50]. All samples of fresh pasteurized apple juice obtained in the present study exceeded the minimum value imposed by the EU, except for the apple juice from the "Gala" cultivar obtained in the blender. The TSS content decreases during storage at room temperature for all juice samples investigated, but it is observed that the decrease is even greater in the case of samples obtained with a blender (on average 26.2%), compared to those obtained by cold pressing (at which the average decrease is only 4.2%).

The contribution of acids to the flavor and quality of food is not limited to the acid content. Sadler and Murphy [30] considers that Brix/acid ratio is a better predictor of flavor than Brix or acid alone. The sugar content of apples is between 9.12 and 13.5 ºBrix according to Sadler and Murphy [30]. The sweetness ratio or Brix / acid ratio is an indicator of the palatability of the juice. The high values of this ratio represent a sweeter taste of the analyzed juice. However, very high values may indicate a tasteless juice [51]. Siguemoto [41] reported for cloudy apple juices TSS/TA between 20.04 and 70.8. For the juice samples obtained in the blender, high values were observed immediately after obtaining the Brix / acid ratios (over 70) depending on the apple cultivar used, and over time these values continued to decrease reaching in the last week of monitoring to values included between 21 ("Gala" apple juice) and 23 ("Braeburn" apple juice) for samples kept at 23 ℃. In the case of samples obtained by cold pressing, values of Brix / acid ratios above 70 were observed immediately after processing, these values are decreasing in time (between 29 (apple juice – "Braeburn" cultivar) and 52 (apple juice – "Gala" cultivar) for samples stored at 23 ℃), as for the samples obtained at blender.

### *3.3. Electrical conductivity*

The electrical conductivity of foodstuffs depends on the characteristics of the product (composition, sugar and salt content, pH, etc.) and is influenced by the heating process itself, in particular the temperature [52].

According to Aadil *et al.* [33], "*the EC of juice is generally due to proteins, fatty acids, minerals and vitamins*". The mean values obtained for the EC of apple juice samples are illustrated in Figure 4.

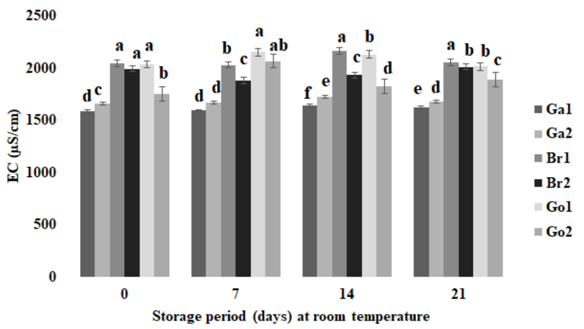


**Figure 4.** Electrical conductivity (EC) evaluation of apple juice samples during storage under ambient conditions (Ga-apples from the "Gala" cultivar, Br-apples from the "Braeburn" cultivar and Go - apples from the "Golden Delicious" cultivar; apple juice samples obtained with 1-blender and 2 - cold pressing juicer). Different lowercase letters (a–f) show significant differences between the groups ($p < 0.05$)

Results show that fresh apple juice pasteurized samples obtained with blender have EC values between 1583 ("Gala" cultivar) and 2046 ("Braeburn" cultivar) µS/cm, while apple samples obtained by cold pressing have EC values ranging from 1662 ("Gala" cultivar) to 1993 ("Braeburn" cultivar) µS/cm. Over time, the EC values of all apple juice samples varied differently depending more on the apple cultivar used but also on the method of processing (Figure 4). EC values for cloudy apple juices reported by Siguemoto [41] were from 1060 to 1860 µS/cm, while Noci *et al.* [53] determined a value of 2100 µS/cm for fresh apple juice.

### *3.4. Color parameters*

Apple juice is a product that most of us have grown up with and is so ubiquitous that it can usually be identified only by aspect. The main component of this identification is color. Therefore, a distinctive golden hue characterizes apple juice. Color measurement, which is a very important analysis of apple juice during production and storage, is performed to observe the color stability of apple juice [54]. Color is not the only critical aspect of apple juice, for example turbidity which is caused by "tannins, proteins or polysaccharides, either alone or in combination" produces opalescence of juices [54]. Even though the demand for natural-looking juices is growing [55], most producers are still looking to produce clear juices. Results of color parameters of apple juice samples during storage at room temperature are illustrated in Table 1.

**Table 1.** Color parameters of apple juice samples during storage at room temperature

| | Sample | *L** | *a** | *b** | BI |
|---|---|---|---|---|---|
| **Apple juice samples** | Ga1 | 21.06 c ± 0.53 | -0.45 b ± 0.02 | 5.77 b ± 0.11 | 29.65 ab ± 1.65 |
| | Br1 | 19.57 d ± 0.04 | -0.02 a ± 0.04 | 5.62 b ± 0.31 | 32.98 a ± 2.34 |
| | Go1 | 20.18 cd ± 0.63 | 0.05 a ± 0.03 | 5.38 b ± 0.12 | 30.53 a ± 2.05 |
| | Ga2 | 20.18 cd ± 0.63 | 0.05 a ± 0.03 | 5.38 b ± 0.12 | 30.53 a ± 2.05 |
| | Br2 | 28.77 a ± 0.30 | -0.96 d ± 0.05 | 8.97 a ± 0.70 | 33.74 a ± 3.35 |
| | Go2 | 22.65 b ± 0.31 | -0.73 c ± 0.05 | 5.41 b ± 0.21 | 24.17 b ± 1.80 |
| **Apple juice samples (7th day)** | Ga1 | 20.16 b ± 0.19 | 0.26 a ± 0.03 | 5.74 c ± 0.05 | 33.70 a ± 0.81 |
| | Br1 | 17.73 c ± 0.04 | 0.07 b ± 0.04 | 4.49 e ± 0.02 | 28.81 c ± 0.23 |
| | Go1 | 23.12 a ± 0.68 | -0.70 e ± 0.03 | 6.45 b ± 0.17 | 29.57 bc ± 2.08 |
| | Ga2 | 20.37 b ± 0.21 | -0.19 c ± 0.04 | 5.08 d ± 0.02 | 27.25 c ± 0.25 |
| | Br2 | 20.65 b ± 0.40 | -0.67 e ± 0.02 | 4.09 f ± 0.08 | 19.07 d ± 0.83 |
| | Go2 | 23.44 a ± 0.19 | -0.51 d ± 0.01 | 6.78 a ± 0.01 | 31.62 ab ± 0.24 |
| **Apple juice samples (14th day)** | Ga1 | 20.11 bc ± 0.97 | 0.41 a ± 0.03 | 3.96 cd ± 0.27 | 23.12 a ± 3.00 |
| | Br1 | 19.44 c ± 0.02 | 0.13 b ± 0.03 | 4.63 b ± 0.02 | 27.10 a ± 0.11 |
| | Go1 | 24.50 a ± 0.58 | -0.57 e ± 0.03 | 5.80 a ± 0.29 | 24.60 a ± 2.22 |
| | Ga2 | 21.38 b ± 0.78 | -0.05 c ± 0.01 | 4.39 bc ± 0.26 | 22.35 a ± 2.54 |
| | Br2 | 25.21 a ± 0.20 | -0.31 d ± 0.02 | 3.67 d ± 0.17 | 14.45 b ± 0.69 |
| | Go2 | 23.94 a ± 0.40 | -0.12 c ± 0.03 | 5.41 a ± 0.17 | 24.67 a ± 1.48 |
| **Apple juice samples (21st day)** | Ga1 | 21.09 e ± 0.62 | 0.08 a ± 0.11 | 5.51 ab ± 0.33 | 29.86 a ± 1.51 |
| | Br1 | 22.49 d ± 0.02 | -0.51 c ± 0.04 | 3.88 c ± 0.03 | 16.78 e ± 0.14 |
| | Go1 | 26.29 a ± 0.05 | -1.07 d ± 0.02 | 5.51 ab ± 0.02 | 19.83 d ± 0.04 |
| | Ga2 | 24.48 b ± 0.08 | -0.19 b ± 0.02 | 5.50 ab ± 0.03 | 24.27 c ± 0.04 |
| | Br2 | 23.52 c ± 0.31 | -0.08 ab ± 0.05 | 5.33 b ± 0.28 | 24.83 c ± 1.05 |
| | Go2 | 23.93 bc ± 0.05 | -0.01 ab ± 0.11 | 5.92 a ± 0.07 | 27.72 b ± 0.03 |

Values are mean ± standard deviation ($n = 3$). Means that do not share a letter are significantly different ($p \leq 0.05$).

The apple juices obtained have a dark color, because according to Hunterlab [56] low values of L* (0-50) indicate dark, and during storage the values vary but do not exceed 50. This may be due to the fact that the samples with apple juice was not filtered. The values of a* measured for some samples of freshly pasteurized apple juice (Ga1, Br1, Br2 and Go2) were in the negative region, which means more green, while for Go1 and Ga2, the values of a* were located in the positive region, which means more to red. During storage at room temperature, the values of a* varied, which means that the color of the juice changed, reaching the 21st day to measure for almost all samples negative values, except for the apple juice Ga1 which had a positive value of the parameter a*. Positive values of b* color parameter were registered for all apple juice samples, which means yellow color. The browning increases with temperature, thus the BI of apple juices fresh pasteurized were between 24.17 and 33.74. BI varies during the storage and the variations are depending on the apple cultivar and processing method.

### *3.5. Sensory evaluation*

Figure 5 shows the results obtained from the sensory analysis of the juice samples obtained from the three types of apples chosen ("Gala", "Braeburn" and "Golden Delicious").

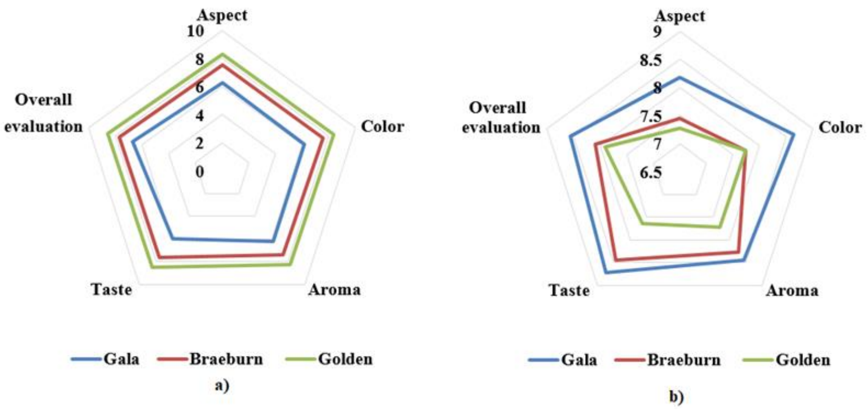


**Figure 5.** Sensory evaluation of apple juice samples obtained with: a) blender and b) cold pressing juicer

It can be seen from Figure 5a that the “Golden Delicious” apple juice obtained with the blender was the most appreciated by the evaluators ($8.54^{a} \pm 0.24$ in the general evaluation), followed by the apple juice of the “Braeburn” cultivar ($7.72^{c} \pm 0.38$) and the apple juice of the “Gala” cultivar ($6.72^{d} \pm 0.70$). The taste and color of the juice of the “Golden Delicious” cultivar, as well as of the “Braeburn” cultivar were the most appreciated, while for the juice of the “Gala” cultivar the appearance (aspect) received the highest score (Figure 5a). In the case of juices obtained by cold pressing, the ranking is reversed as follows: “Gala” apple juice obtained the highest score ($8.54^{a} \pm 0.15$), while “Golden Delicious” apple juice received the lowest score in the overall evaluation ($7.90^{b} \pm 0.34$). The taste and color of the apple juice “Gala” obtained by cold pressing were the most appreciated, while for the apple juice of the “Braeburn” cultivar the evaluators appreciated more the taste and aroma (Figure 5b).

### *3.6. Phytochemical analysis*

Results obtained for phytochemical tests were illustrated in Figure 6.

In the case of the test for flavonoids (cyanidine test) an effervescence was observed and also a red brick color, which indicates the presence if flavonoids (Figure 6a). A blue-green color indicated the presence of tannins as can be seen in Figure 6b. The presence of terpenoids was indicated by the formation of a reddish brown color at the interface (Figure 6c). In the case of phenol testing, after 10 minutes, since ferric chloride was added, the formation of a green precipitate was observed (Figure 6d).

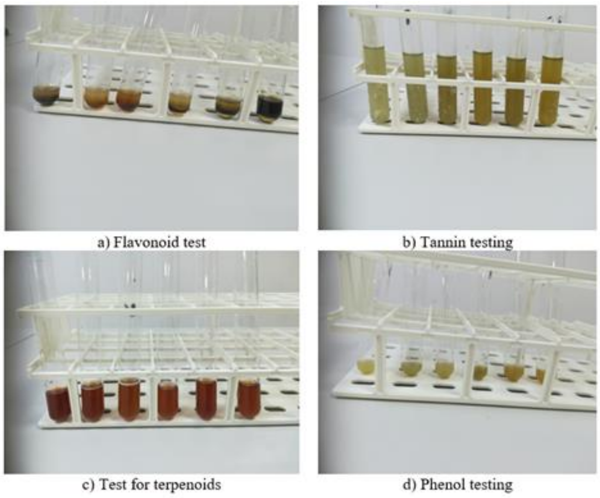


**Figure 6.** Phytochemical tests performed on fresh pasteurized juice samples

### *3.7. Correlations of measured data*

In Tables 2 and 3 are presented positive and negative correlations between physico-chemical parameters measured or calculated for apple juice extracted by blender and cold pressing juicer, respectively.

**Table 2.** Correlations between physico-chemical parameters measured or calculated for apple juice extracted by blender (Pearson correlation)

| | M | aw | pH | TA | TSS | EC | L* | a* | b* |
|---|---|---|---|---|---|---|---|---|---|
| aw | -0.879 | | | | | | | | |
| pH | **0.968** | -0.73 | | | | | | | |
| TA | -0.854 | 0.503 | **-0.958** | | | | | | |
| TSS | **-0.973** | 0.746 | **-0.999*** | **0.951** | | | | | |
| EC | **-0.968** | 0.73 | **-0.999*** | **0.958** | **0.999*** | | | | |
| L* | 0.795 | -0.41 | **0.923** | **-0.995** | **-0.913** | **-0.923** | | | |
| a* | **-0.995** | 0.826 | **-0.988** | **0.903** | **0.992** | **0.988** | -0.853 | | |
| b* | **0.911** | **-0.997*** | 0.778 | -0.565 | -0.792 | -0.778 | 0.475 | -0.865 | |
| BI | -0.522 | 0.052 | -0.721 | 0.889 | 0.704 | 0.721 | **-0.932** | 0.607 | -0.125 |

* Statistically significant at $p < 0.05$. Values in bold show very high positive/negative correlation (according to Mukaka [57]).

**Table 3.** Correlations between physico-chemical parameters measured or calculated for apple juice extracted by cold pressing juicer (Pearson correlation)

| | M | aw | pH | TA | TSS | EC | L* | a* | b* |
|---|---|---|---|---|---|---|---|---|---|
| aw | **0.999*** | | | | | | | | |
| pH | **-0.928** | **-0.946** | | | | | | | |
| TA | 0.582 | 0.622 | -0.843 | | | | | | |
| TSS | 0.582 | 0.622 | -0.843 | **0.999*** | | | | | |
| EC | **0.986** | **0.993** | **-0.978** | 0.711 | 0.711 | | | | |
| L* | **0.983** | **0.991** | **-0.981** | 0.722 | 0.722 | **0.999*** | | | |
| a* | -0.745 | -0.778 | **0.94** | **-0.976** | **-0.976** | -0.846 | -0.855 | | |
| b* | **0.996** | **0.99** | -0.891 | 0.506 | 0.506 | **0.967** | **0.962** | -0.682 | |
| BI | 0.69 | 0.653 | -0.371 | -0.187 | -0.187 | 0.559 | 0.545 | -0.031 | 0.753 |

* Statistically significant at $p < 0.05$. Values in bold show very high positive/negative correlation (according to Mukaka [57]).

In the case of apple juice samples extracted by blender strongly positive correlation were observed between M and pH (0.968), M and b* (0.911), pH and L* (0.923) and also between TA and TSS, TA and EC, TA and a*, TSS and EC, TSS and a*, EC and a* (Table 2), while strongly negative correlation were noticed between M and TSS (-0.973), M and EC (-0.968), M and a* (-0.995), aw and b* (-0.997), pH and TA, pH and TSS, pH and EC, pH and a*, Ta and L*, TSS and L*, EC and L*, L*and BI (Table 2). Regarding the correlations between physico-chemical parameters determined for apple juice extracted by cold pressing juicer (Table 3) it was noticed that some strongly correlations are similar (with the same sign) with those observed in Table 2, for example: M and b*, pH and EC, TA and TSS, or with inverted sign like M and pH, M and EC, aw and b*, pH and L*, pH and a*, TA and a*, TSS and a*, EC and L*. In Table 3, there were observed strongly correlation between others parameters like M and aw (0.999), M and L* (0.983), aw and pH (-0.946), or between aw and EC, aw and L*, EC and b*, L* and b*.

## 4. Conclusions

Color, sugar content and acid composition influence the quality of apple juice, but also the acceptability of the consumer. Cloudy apple juices were produced from three different apple cultivars using two different extraction devices. Due to the fact that the juices were not filtered, the color of the apple juices was darker. This aspect could be observed with the naked eye, but also by determining the color parameters. The minimum value imposed by the EU of 11.2. °Brix, was exceeded by all juice samples investigated except one obtained by blender extraction. As expected, it was observed that over time the total solids content decreases in all samples, but more in the samples obtained using the blender. The results showed that the malic acid contents are lower on the first day after obtaining, after which they vary and increase until the last day of analysis, especially in the case of samples obtained by blender extraction. The increase in malic acid content is lower in the case of juice samples obtained by cold pressing. It was observed, by using simple tests to identify the presence of phytochemicals in the apple juices obtained, that all juice samples contain flavonoids, tannins, terpenoids and phenol, their content differing of course depending on the apple variety and processing method. Based on the results of sensory evaluation, appreciation decreases in the following order: Ga2 > Go1 > Br2 > Go2 > Br1 > Ga1, therefore the most preferred apple juices are those obtained by cold pressing of "Gala" apples, and "Golden Delicious" apples if the blender is used to extract the juice.

## Conflict of interest

Authors declare no conflict of interest.

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