

ORIGINAL RESEARCH PAPER

CHARACTERIZATION OF CLOUDY APPLE JUICE OBTAINED FROM SIX AUTHENTIC VARIETIES FROM VALEA DÂMBOVIȚEI

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Abstract: The cloudy apple juice obtained from 6 varieties of apples is analyzed in this study (EJ7). Organography and analytical determinations highlighted the Sirius apple variety. Using the prediction model of the values of the quality indicators, it was possible to estimate: soluble dry matter (TTS), titratable acidity (TTA), total anthocyanins content (AT), ascorbic acid content (AA) in the blend. These values are closely related to the actual ones. Thus for the blend (EJ7): $TTA = 15.5^{\circ}Bx$, $TA = 0.5 \text{ g/100mL}$ expressed in malic acid, $AT = 6.8 \text{ mg} \cdot \text{L}^{-1}$ cyanidin-3-glucoside. The content of ascorbic acid decreases compared to that of apples. By generating the linear regression equation for the correlation of relative density and kinematic viscosity values, a correlation index of 58 % was obtained. When blending cloudy juices, the influencing factors for the values of the quality indicators are: the size of the particles of the turbidity, the variety of apple and the proportion of the blend, exposure to high temperature, the action of oxygen. Blending juices obtained from different apple varieties, from the small production of an orchard is beneficial because it is possible to obtain a juice variant with superior sensory characteristics, as was also obtained in this study (EJ7 obtained a maximum score of 5 points) and with quality indicators with values corresponding to the assortment and predictive. A larger quantity of juice with constant quality characteristics is also obtained.

Keywords: apple varieties, cloudy apple juice, juice quality, organography

INTRODUCTION

The apple (*Malus domestica*) belongs to the *Rosaceae* family and can be considered to be, along with oranges, the most used raw material for the manufacture of juices. It is a false fruit and has seeds covered by pulp which is the main source of juice [1]. It grows in temperate regions and develops well in Romania as well. Worldwide production is increasing (81,655 tons annually 2022/2023) with the appearance of new apple varieties [2]. The apples contain valuable salt components that also end up in the juice. These are: sugars (glucose, fructose, sucrose), vitamin (B₆, C, E), organic acids (malic, citric, succinic, tartaric), trace elements (copper, manganese, zinc, iron) [3]. If one opts for the cloudy version of the juice, then part of the amount of dietary fibers, polyphenols, flavonoids and other antioxidants, protein and fatty substances end up being consumed for the benefit of the human body [4, 5]. Apple juice production is expected to reach \$22.4 billion by 2027. Apple juice is made by crushing and pressing an apple and has a variety of health benefits [6].

A large number of cultivars are cultivated, specific ones often associated with a certain geographical region. More than 60 varieties of apples are grown in *Romania*, among which we mention: *Florina*, *Ionaprim*, *Domnesc*, *Crețesc*, *Renette*, *Generos de Voinești*, *Frumos de Voinești* [7]. In *Romania*, there are juices obtained by blending based on natural cloudy apple juice. Other vegetables used are raspberries, pears, beetroot, carrot and others.

The impact of blending juices is very high on the consumer, because the final effect may be new but superior to the effect of each individual juice taken initially in the work. Attention has been paid to this aspect and the main objective of this study is to obtain a blend of juice from six varieties of apples and evaluate the impact on the consumer and the physicochemical indicators. The collateral objectives are those that contribute to the achievement of the central objective, namely: characterization of apple varieties from the *Dâmbovița* valley, organography and physico-chemical indices, obtaining juices from each studied apple variety, blending them in equal proportions, theoretical estimation of some values of some determined quality indicators and the actual determination of the values, as well as the generation of the regression equation with the calculation of the correlation between the relative density and the kinematic viscosity of juices obtained.

MATERIALS AND METHODS

Materials

They used apples picked from the orchard in Valea *Dâmboviței*, *Romania*, in 2023, which were transformed into cloudy juice. The apple varieties used are: *Florina* (E1), *Red Topaz* (E2), *Starkrimson* (E3), *Sirius* (E4), *Golden* (E5), *Rozela* (E6).

The preparation of the juice is presented in the results and discussion chapter. The juices obtained by extraction and blending are: cloudy juice from apples of the *Florina* variety (EJ1); *RedTopaz* variety (EJ2), *Starkrimson* variety (EJ3), *Sirius* variety (EJ4), *Golden* variety (EJ5), *Rozela* variety (EJ6), cloudy apple juice blend (EJ7). The blending was done in equal proportions from each of the 6 juices.

Methods of analysis

The analysis methods used in this study are: analysis of fresh apples [8]; humidity [%], dry matter [%] [9]; pH [10]; total soluble solid (TSS)[°Bx] [11]; total titratable acidity (TTA)[g/100g expressed in malic acid] [12]; ascorbic acid content(AA)[mg·L⁻¹][13]; total anthocyanin content(AT)[mg·L⁻¹cyanidin-3-glucoside equivalents] [14]; relative density [15]; kinematic viscosity [cSt] [16].

Obtaining juice from the blend

The juices are obtained separately from the apple varieties chosen in this study, by cold extraction. The juices are then blended in equal amounts, in order to obtain a juice variant that will be analyzed later (EJ7).

The equations are used to predict the values of the quality indicators of the blend:

For total soluble solids:

$$EJ1 + EJ2 + EJ3 + EJ4 + EJ5 + EJ6 = EJ7 \quad (1)$$

$$EJ1 \times \frac{TSSJ1}{100} + EJ2 \times \frac{TSSJ2}{100} + EJ3 \times \frac{TSSJ3}{100} + EJ4 \times \frac{TSSJ4}{100} + EJ5 \times \frac{TSSJ5}{100} + EJ6 \times \frac{TSSJ6}{100} = EJ7 \times \frac{TSSJ7}{100} \quad (2)$$

For the estimation of ascorbic acid content (AA):

$$EJ1 \times \frac{AAEJ1}{100} + EJ2 \times \frac{AAEJ2}{100} + EJ3 \times \frac{AAEJ3}{100} + EJ4 \times \frac{AAEJ4}{100} + EJ5 \times \frac{AAEJ5}{100} + EJ6 \times \frac{AAEJ6}{100} = EJ7 \times \frac{AAEJ7}{100} \quad (3)$$

For the estimation of acid content by total acidity (TTA):

$$EJ1 \times \frac{TTAEJ1}{100} + EJ2 \times \frac{TTAEJ2}{100} + EJ3 \times \frac{TTAEJ3}{100} + EJ4 \times \frac{TTAEJ4}{100} + EJ5 \times \frac{TTAEJ5}{100} + EJ6 \times \frac{TTAEJ6}{100} = EJ7 \times \frac{TTAEJ7}{100} \quad (4)$$

For the estimation of total anthocyanin content (AT):

$$EJ1 \times \frac{ATEJ1}{100} + EJ2 \times \frac{ATEJ2}{100} + EJ3 \times \frac{ATEJ3}{100} + EJ4 \times \frac{ATEJ4}{100} + EJ5 \times \frac{ATEJ5}{100} + EJ6 \times \frac{ATEJ6}{100} = EJ7 \times \frac{ATEJ7}{100} \quad (5)$$

Sensory analysis

For the sensory analysis, the scoring method is used, with a small number of points (5 points). The characteristics analyzed are: appearance, taste, smell, color and for each one a score of 1-5 points is received. The importance coefficients are: taste 0.4, smell 0.3, appearance 0.2, color 0.1 [17]. The sensory analysis of the obtained juice was carried out by panelists who prefer apples and apple juice and who were trained in this field. They were chosen from the "Goga Ionescu" High School in Titu, Dâmbovița, Romania and they are students in the "technician" classes' gastronomy. They were trained for two weeks before the final juice tasting.

Statistical analysis

For each working variant, 3 samples were analyzed. The "t-student" method was used to process the results, for a significance interval of 0.05, with two degrees of freedom.

RESULTS AND DISCUSSION

Organography of apple varieties

The characteristics for the apple varieties and the mean values of the 3 samples are presented in Table 1. These 6 varieties represent the orchard in the *Dâmbovița* valley, the morphological parts are specific and influence the juice yield. Thus, the greater the amount of pulp, the higher the yield in juice. This aspect is also influenced by the weight and size of the fruit. In the category of large apples, the varieties fall in the order $E4 > E3 > E6 > E1 > E5 > E2$. In a previous study, juice yield values were published. The range of values was 61.2 - 64.3 % with the highest value given by the variety E4 (Sirius) which was also found to be the largest [18].

Tabel 1. Organographic and physico-chemical elements of some apple varieties

Characteristics	Apple variety					
						
	E1	E2	E3	E4	E5	E6
Weight [g]	138.4 ± 0.8 ^a	112.44 ± 0.4	173.5 ± 1.1	241.1 ± 1.9	133.3 ± 1.3	142.2 ± 0.78
Shell [%]	19.01 ± 0.15	15.03 ± 0.13	16.34 ± 0.09	16.04 ± 0.66	20.45 ± 0.5	14.37 ± 0.5
Pulp [%]	75.26 ± 0.9	90.8 ± 0.23	74.91 ± 1.1	76.5 ± 2.3	70.9 ± 0.51	77.34 ± 0.8
Cavity [%]	2.83 ± 0.08	6.19 ± 0.1	5.13 ± 0.8	3.32 ± 0.19	4.32 ± 0.08	4.9 ± 0.026
Seeds [%]	0.35 ± 0.06	0.42 ± 0.009	0.18 ± 0.44	0.08 ± 0.001	0.32 ± 0.28	0.33 ± 0.46
Calyx [%]	0.7 ± 0.1	0.2 ± 0.6	0.84 ± 0.02	1.17 ± 0.04	1.54 ± 0.5	0.94 ± 1.1
The gallows [%]	0.8 ± 0.03	1.59 ± 0.07	1.41 ± 0.06	1.66 ± 0.5	2.45 ± 0.25	0.75 ± 0.8
Circumference [cm]	70 ± 0.7	75 ± 0.6	75 ± 0.93	85 ± 0.11	75 ± 0.3	75 ± 0.31
Height [cm]	6.5 ± 0.6	5.8 ± 0.3	7 ± 0.21	7 ± 0.9	6 ± 0.32	5.4 ± 0.7
Diameter [cm]	7 ± 0.015	7 ± 0.09	7.5 ± 0.1	8 ± 0.61	6.8 ± 0.35	7 ± 0.2
Moisture [%]	81.6 ± 2.4	81.8 ± 0.2	82.3 ± 0.4	83.4 ± 0.14	82.8 ± 0.21	82.5 ± 0.5
Total dry matter [%]	18.4 ± 0.0	18.2 ± 0.0	17.7 ± 0.0	16.6 ± 0.0	17.2 ± 0.0	17.5 ± 0.0
pH	3-3.5	2.5-3	4-4.5	3-3.5	4-4.5	3.5-5

^aValues present as mean ± SD, using the "t-test" (n = 3) for all result.

Technological studies

The preparation of cloudy apple juices from the chosen varieties was carried out according to the scheme shown in Figure 1.

A system of equations with 2¹ unknowns is generated to estimate the value of the quality indicators of the juice obtained by blending (EJ7). The input quantities are the values for total acidity, total solubil solid, ascorbic acid and total anthocyanin content, and as output quantities the same quality indicators for the blended juice (EJ7).

To estimate the total soluble solid, Equations 1 and 2 are used and a TSS value of EJ7=15.93 °Bx is obtained and the actual refractometrically determined value is 15.5 °Bx. Equations 1 and 3 are used to estimate the content of ascorbic acid and it is obtained for the AA coupling of EJ7 = 4.36 mg/100g and actually 3.8 mg/100g.

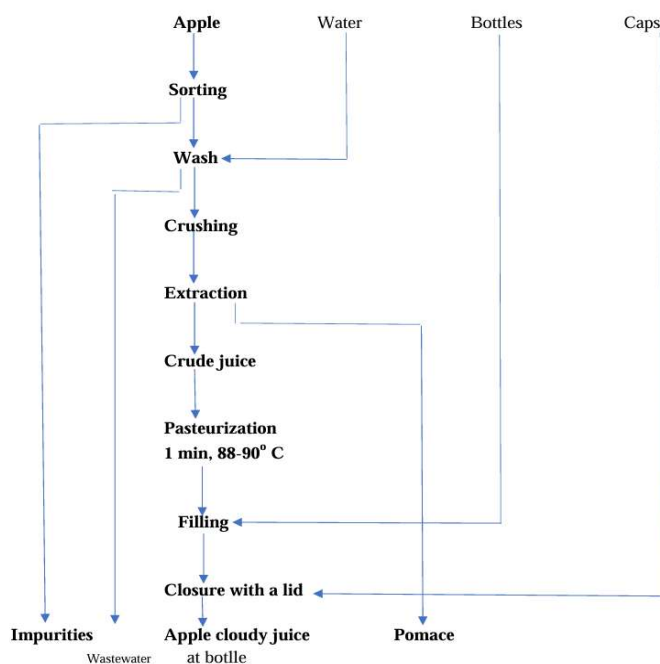


Figura 1. Technological flow scheme for obtaining cloudy apple juice

To estimate the total acidity, Equations 1 and 4 are used to obtain the TA value of EJ7 = 0.55 g/100g expressed in malic acid, and actually 0.5 g/100g expressed in malic acid. Equations 1 and 5 are used to estimate the total anthocyanin content. The AT value of EJ7 = 4.01 mg·L⁻¹ cyanidin-3-glucosides is obtained and the actual value is 6.87 mg·L⁻¹ cyanidin-3-glucosides. These values will be compared with those actually obtained and represented graphically in Figures 2 and 3.

Physico-chemical characteristics of juices

Ascorbic Acid content and total soluble solid

An evolution of quality indicators such as soluble dry matter, ascorbic acid, from the apple variety to the blended juice (EJ7) is presented in Figure 2.

Thus, the content of soluble dry matter in apple varieties is the same as that of apple juice obtained using the scheme in Figure 1, with small exceptions and is in the range of values 14 - 17 °Bx. The TSS value for EJ7 is 15.5 °Bx. The theoretical estimate using the total and partial material balance equations was 15.93 °Bx

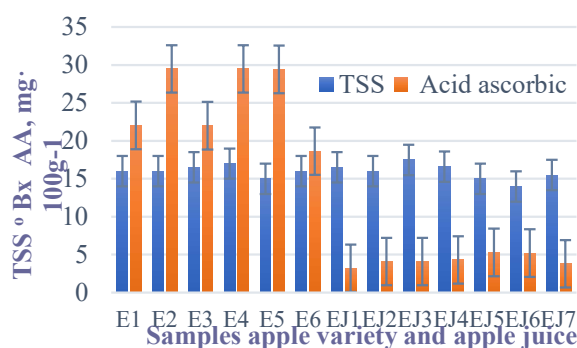


Figure 2. Evolution of the content of total soluble solid (TSS) and ascorbic acid (AA) from apple varieties (E1-E6) to apple juice (EJ1-6) and the variant obtained by blended (EJ7) values present as mean $\pm$ SD, using the "t-test" ($n = 3$) for all results

This is because the soluble components of the apple migrate into the juice and the blend was made with equal contributions of the varieties. Values are real and influenced by apple varieties. In other studies °Brix values are 11.2 - 10.65 °Bx [19] with lower values for the pasteurized version of the juice.

The ascorbic acid content of apples is 18.64 - 29.49 mg/100g, and in cloudy juices 3.2 - 5.3 mg/100mL. This variation is not the same for different varieties of apples and is also transmitted to the respective assortment of juice. The value for the blend is 3.8 mg/100g and the estimated one is 4.36 mg/100g. The decrease in vitamin C content from apple to juice is natural and influenced by exposure to the action of oxygen and heat treatment. The estimated value is higher compared to the actual one in blending (EJ7) due to different mixing of large particles.

Evolution of total anthocyanin content, total acidity and pH

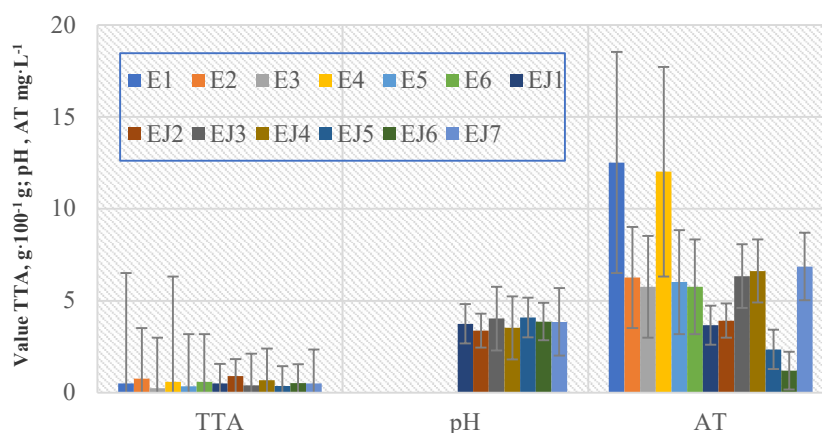


Figure. 3 Evolution of titratable acidity (TTA), pH values and total anthocyanin content (AT) from apples (E1-6) to apple juice (EJ1-6) and to coupage (EJ7) values present as mean $\pm$ SD, using the "t-test" ($n = 3$) for all results

The concentration in vitamin C varies from 2 to 35 mg/100g [20]. This variation is due to varieties, growing conditions and environmental factors [21].

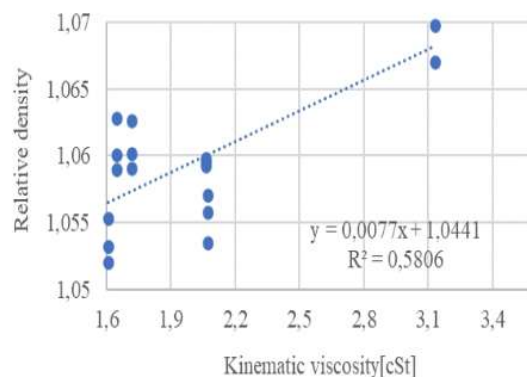
The evolution of the total titratable acidity (TTA) from the studied apple varieties to juices is an increase from apples to juice, on average by 15 %. The titratable acidity value for the blend is 0.5 g/100 and the theoretically estimated one is 0.55 g/100g expressed in malic acid. In the literature, TTA values for apple juice of 0.34 g/100g expressed in malic acid are specified [22].

The pH values range from 3.372 to 4.084, correlating with the total acidity, suggesting that as the acidity increases, the pH value decreases. This aspect is also shown in a study of other apple varieties and the pH is in the range 3.75 - 3.61 [19]. The increase in acid components, embodied in the increase in acidity and decrease in pH , in pasteurized juice is due to the action of temperatures up to 83 °C [23].

The content of total anthocyanins (AT) in apple varieties is 5.76 - 12.02 mg·L⁻¹ cyanidin-3-glucosides with the highest amount (12.52 mg·L⁻¹ cyanidin-3-glucosides) for apple variety E1(Florina). The AT values for the obtained juices are lower by about 50 %. The estimated value of the total anthocyanin content is 4.01 mg·L⁻¹ cyanidin-3-glucosides compared to the actual value of 6.87 mg·L⁻¹ cyanidin-3-glucosides for the EJ7 blend. The juice is cloudy as indicated by the density and viscosity values represented in Figure 4. Thus, 95 % of the particles have sizes smaller than 2.5 µm [24]. They are relatively stable and contain cell fragments, chromoplasts, protein-polyphenol complex, polysaccharides, fatty particles [25] to which smaller molecules adhere. That is why I consider that the determined AT value is different from the one estimated at the time of determination, a particle was larger and thus the AT content was higher in the mixture (EJ7).

Relative density and kinematic viscosity

Figure 4 shows values of the relative density determined for the same juice samples, using different physical principles ("U-tube" principle, weighing an exactly measured volume, *Archimedes'* principle) and of the kinematic viscosity with a linear correlation ratio close to limit (58 %).



The flow time required to calculate viscosity is influenced by density, meaning by the chemical composition and particle size. But the weak correlation suggests that there are other influencing factors that need to be studied in the future. The juice obtained by blending EJ7 follows the same trend, falling perfectly within the permuted values, for the relative density of 1.0592 - 1.0598 and the kinematic viscosity of 2.0643 cSt.

Sensory analysis

The results of the sensory analysis are surprising (Figure 5). Although the values of the final score for the juices are between 2.75 points and 4.5 points, for the blended version it is 5 points, meaning the maximum value for all the characteristics studied.

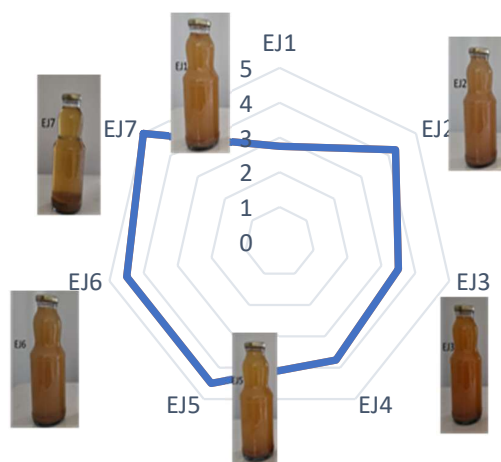


Figura 5. Radar overall acceptability diagram of the sensory score for the studied characteristics of the juice obtained by extraction (EJ 1-6) and the variant obtained by blending (EJ7)

The flavor of pasteurized apple juice is given by the 57 original components and the 37 components generated by the action of heat treatment (pasteurization). Those that are also present after heat treatment are: acetic acid, butyl acetate, ethyl hexanoate, hexanolhexyl acetate [26]. These flavor components influence consumer behavior and are missing in some varieties. In the juice sample obtained by blending (EJ7) all the important volatile components in the juices of the apple varieties were found. That is why the blend has a higher sensory score.

CONCLUSIONS

An apple juice blend was obtained from the juices of 6 varieties of apples. It seems that it was a suitable choice because in the sensory examination it received a maximum score. The determined quality indicators are the primary ones, but they showed the difference between the apple varieties, the juice assortments obtained by extraction and blending. Thus, when blending, the flavor of the juice is enhanced and the values of the other characteristics are in the range specific to cloudy juice and in accordance with the theoretical predictions. The juice has a particularity, namely the turbidity which is characterized by the relative density and viscosity. The correlation of the values is

approximately 58 %, which shows that there are other influencing factors compared to those studied (apple variety, type of juice, blending ratio).

In the future this way of mixing all the juices obtained from the apples in the orchard can be beneficial because from small quantities a larger amount of juice is obtained with superior characteristics and constant quality.

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