Studii şi Cercetări Ştiinţifice 2018, **19** (3), pp. 257 – 267
Chimie şi Inginerie Chimică, Biotehnologii, Industrie Alimentară

Scientific Study & Research
Chemistry & Chemical Engineering, Biotechnology, Food Industry *ISSN 1582-540X*

ORIGINAL RESEARCH PAPER

COMPARATIVE ANALYSIS OF THE AROMATIC, SENSORY PROFILE OF THE ELDER FLOWER (*Sambucus nigra*) COMPOTE, AN INNOVATIVE PRODUCT, WITH BEVERAGES OF "*ELDER FLOWER JUICE*" TYPE

Maria Lidia D. Iancu*

"Lucian Blaga" University of Sibiu, Faculty of Agricultural Sciences, Food Industry and Environmental Protection, Department of Agricultural Sciences and Food Engineering, 5-7, Ion Raţiu Street, Sibiu, 550012, Romania

*Corresponding author: maria.iancu@ulbsibiu.ro

Received: January, 30, 2018
Accepted: July, 27, 2018

Abstract: Wild elder flowers can be used for making a very popular beverage which is called *"elder flower juice"*. Four samples have been analyzed in this study, different by recipe, method of preserving and encapsulating the flavors. Their aromatic profile has been studied and peculiarities of the descriptors have been found following the investigation using the principal component analysis technique, due to the very large number of results (728). Thus, it has been observed that out of the 13 descriptors analyzed by 14 panelists, for the 4 samples, those who give the particularities of the assortment, but also those that are common are: vanilla, freshly cut grass, lemon, rose and wet wood. The close competition was between classic elder flower juice and compote. Thus, for the new product, the fresh elder flower compote, the predominant flavor descriptor was the floral rose one and for the classical fermented elder flower juice was the fruity vanilla and the freshly cut grass. The overall perception of the new product was to place it on the second position (score 2.14) after the traditional elder flower juice (score 2.57).

Keywords: *aromatic descriptor, compote technology, elder flower, fermented drink, unfermented*

INTRODUCTION

Sambucus nigra L. is a plant variety in Romania's wild flora, which provides the consumer with raw material (inflorescence, leaves, fruits) for consumption and for health [1, 2]. It has been used since ancient times. Inflorescences are used for the fermented juices, with sugar and lemon, and they are drunk freshly made or preserved [3 – 5]. Elder belongs to the *Adoxaceae* family, the *Sambucus* genus. Its scientific name is *Sambucus nigra* L. genotype. Black Elder is a shrub that grows in the spontaneous flora of Romania, Central Europe, wild Asia and North Africa. It has white clustered flowers, and small round black fruits [6]. The morphological parts to be used are the inflorescence for fermented juices and confitures, the small black fruits for the crafted undistilled alcoholic beverage production, jam, juice [5], whereas the leaves, shoots and bark for external use.

Elder flowers are an efficient remedy for influenza and colds, gout, lung infections and skin diseases, sore throat, hay fever, arthritis. They have a diuretic effect. Elder tea increases the milk supply of breastfeeding women. It is a natural remedy in obesity or constipation [7]. According to the European Medicines Agency, the flowers are rated as medicinal products [8 – 10].

Elder flower extracts are used to make yoghurt, wine, ice cream, candy and cakes [3, 11, 12] or are eaten as such. The elder flower beverage is very popular in the world (England, Sweden, Denmark, Austria) [3, 11, 12] but also in Romania where it is called "*socată*". The sensory notes of the elder flower beverages are: floral, honey, fruity, sweet-sour, grass notes. The recipe exists in the literature [3, 4].

The characteristic flavor is given by the numerous volatile components that have been identified. There are several species of *Sambucus nigra*, about 89, each with its aromatic distinctiveness. The elder flower extract contains: sucrose, citric acid, ascorbic acid, sodium benzoate and numerous volatile components, 58 volatile components were identified in the elder flower extract. There are correlations between the volatile components and the sensory profile of the diluted elder flower extract [13, 14]. The chemical substances identified by GC-FID and GC-MS contributing to the specific flavor are: alcohol, aliphatic aldehyde, linalool, linalool derivatives, α-terpineol, unoxidized monoterpenes [13]. The HS-SPME and GC_GC-ToFMS technique was used to identify the volatile terpenes [15].

The relationship between the volatile components and the aroma profile is important. Thus, the floral and green elder flavor is given by 4-methyl-3penten-2-one, (Z)-β ocimene, nerol oxide, linalool oxide, rose oxides, hotrineol, linalool, nonanal and α-terpineol [15]. The fruity aroma is associated with pentanal, heptanal, octanal, limonene, β-damascenone, and esters of carboxyl-acid with alcohols. The fresh, grassy flavor is associated with hexanal, 1 hexanol, (Z)-3-hexen-1-ol, (E)-hexen-1-ol, (E,E)-2-4-heptadienal and (E)-2 octenal [5, 16 – 19].

The objective of this study is to process the fresh elder flowers of the wild flora of Romania in the form of: elder flower beverage called "*socată*" and a new product, following the technology of preparing the compote, the description of the technological scheme for obtaining it, the study of the aromatic profile by sensory analysis. The secondary objective is the comparative analysis of the aromatic profiles of the prepared elder beverages, the selection by Principal Component Analysis (PCA) of the

representative flavor components, preferred by the panelists and the identification of the influence factors.

MATERIALS AND METHODS

Raw materials: Elderflower wild, *Sambucus Nigra* was collected, from the Teleajen Valley, Romania. Only fresh flowers were used.
The preparation of drinks elderflower "***Socată***": 300 g of elder inflorescences, 8000 g of tap water, 1200 g of sugar, 200 g of lemon slices with peel, Pakmaya compressed yeast (commercially) containing *Saccharomyces cerevisiae* species cells, 5 g. The samples have undergone fermentation for 72 hours at 25 °C. The technological preparation scheme and the product image are shown in Figure 1A. Coded samples were thus prepared is: fermented "*socată*", with yeast, freshly consumed (code-135); fermented "*socată*" with yeast, preserved by pasteurization (code-277); fermented, without yeast, preserved by pasteurization (code-389).
Elderflower compote (innovative product): elder 10 g fresh flowers, 10 g of lemons slice with peel, syrup with concentration of 15 % (sugar + water). These are the amounts needed for a 400 mL in a container. The technological scheme of preparation and the product image are shown in Figure 1B. Pasteurized compote samples were analyzed after 20 days of storage at 18 °C (sample code 453).

Sensory evaluation

The selection of the components that make up the aromatic profile was made in accordance with the literature [5, 18 – 24]. These are: flowery-sweet (a), fruity-vanilla (b), flowery-elder leaves green (c), floral-lemon (d), flowery fresh elderflower (e), green fruits (f), floral dry elderberry (g), freshly cut grass (h), garlic (i), residual (j), wet wood (k), sweet wood (licorice) (l), floral-rose (m). A panel of 14 members, boys and girls, with ages contained 20-25 years, students of "*Lucian Blaga*" University of Sibiu, faculty of *Agricultural Sciences, Food Industry and Environmental Protection*, was used. They were previously tested for: availability, level of commitment, overall knowledge of products, health history and a tactile or fragrance quiz. The intensity of flavor components was evaluated. The flavor descriptors were perceived by the odor and flavor analysis (taste and smell). It was considered the same sweet taste in all samples. A scale of 0 (without flavor descriptor) to 5 (felt at maximum intensity), was used. Being a very popular drink, the reference was the range of flavors memorized by panelists during their lifetime.

Statistical analysis

The multivariate statistical analysis for the prepared beverages and the results obtained for the flavor descriptors are the main analyzed components, principal component analysis that has formed a correlation matrix in the statistical analysis program of OriginPro9 32. The PCA technique is used to convert the parameters into factors which are called main components.

RESULTS AND DISCUSSION

Description of the technological scheme of obtaining the innovative product called "*Elder flower compote*"

The technological schemes of preparing the beverage known as *"socată"* and the new product have been discussed. This new product was obtained according to the preservation technique based on the biological abiotic principle and as the process of thermobiosis and pasteurization is the method of preservation.

The traditional procedure of obtaining the elder-flavored beverage is well known (Figure 1B). The novelty of the study consists, at this stage, in developing a scheme to obtain a new product called "*Elder flowers compote"* (Figure 1B). The solid part of the mixture of elder flowers, the sliced lemon, is dosed in the packaging unit. It is covered with the liquid part made of the sugar syrup having a dry matter content which has been calculated without taking into account that of the raw material. The pasteurization operation, at the temperature 90 °C for 20 minutes, contributes to heating the mixture and the solid part. This facilitates the diffusion of liquids and balancing the chemical composition of the liquid part which will be consumed later. During storage, at the temperature 15-18 °C for minim 20 days, this balancing of the soluble, insoluble and volatile components is accomplished. They remain closed in the packing unit until consumed.

Development and analysis of the aromatic profile

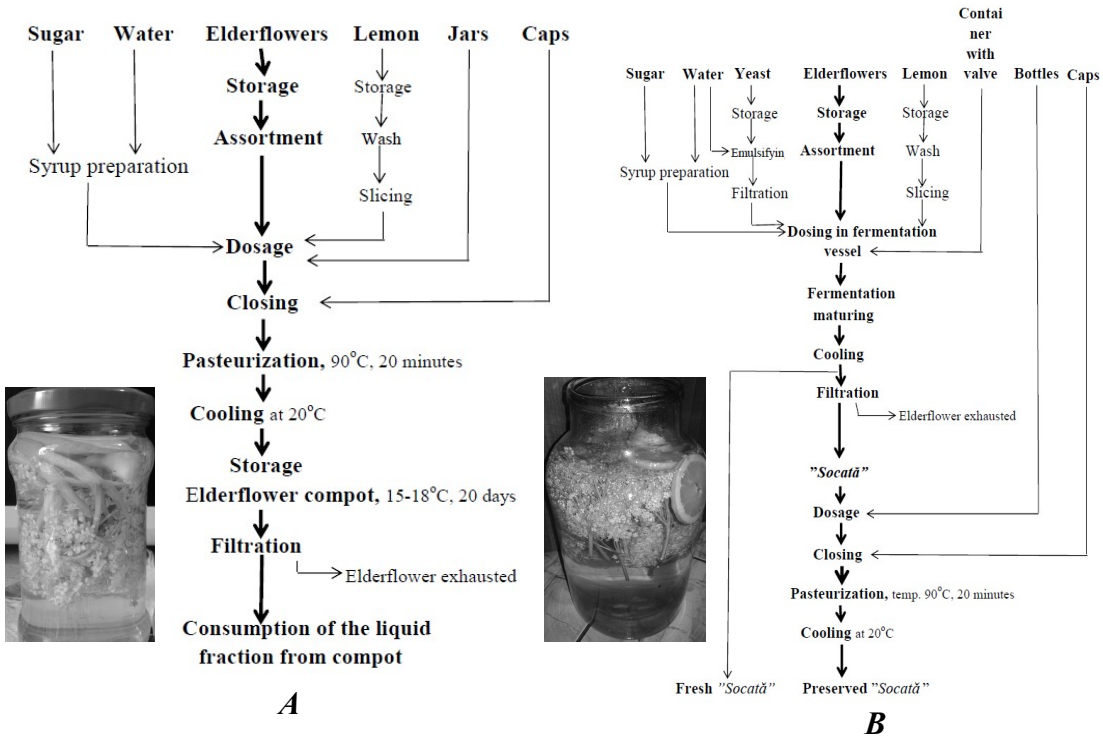


Figure 1. *A) Technological scheme for manufacturing elderflowers compote (the image - the elderflower compote in storage phase);* ***B)*** *Technological scheme of "socată" manufacturing (the image - maturing mash fermentation phase)*

The impact the new product (the compote) and the other samples have on the consumer will be further analyzed by developing and analyzing their aromatic profile.
The results of the aromatic profile made of 13 flavor descriptors for 4 different samples, obtained from 14 panelists (728 results), were analyzed using PCA. Tables 1 and 2 show the significant contribution of each factor to the principal components 135, 277, 389 and 453. The components with the highest numerical value and positive sign significantly contribute to the individualization of the PC (principal component).

Table 1. *Values of volatile components and significance for PC, PC1 and PC2 for 135 and 277 sample*

Flavor descriptors	PC1_135		PC2_135	PC1_277		PC2_277
	Code	Loading	Loading	Code	Loading	Loading
Flowery sweet, a	**a_135**	-0.30948	0.30571	**a_277**	0.10191	-0.39583
Fruity-vanilla, b	**b-135**	0.20467	0.36006	**b-277**	0.20807	-0.30502
Flowery elder leaves green, c	**c_135**	0.09491	0.16375	**c_277**	-0.48269	0.02298
Floral lemon, d	**d_135**	0.1985	0.27258	**d_277**	0.3128	-0.06859
Flowery fresh elderflower, e	**e_135**	-0.25407	0.30643	**e_277**	0.44816	-0.03387
Green fruits, f	**f_135**	0.3253	0.32669	**f_277**	0.34756	0.28121
Floral dry elderberry, g	**g_135**	0.3253	0.32669	**g_277**	0.14165	0.26987
Freshly cut grass, h	**h_135**	0.43533	-0.09432	**h_277**	0.12369	0.44163
Garlic, i	**i_135**	0.29005	-0.00786	**i_277**	-0.20967	0.29923
Residual, j	**j_135**	0.17306	-0.42422	**j_277**	0.24228	0.43773
Wet wood, k	**k_135**	0.2384	-0,41038	**k_277**	0.12004	0.31341
Licorice, l	**l_135**	-0.21568	0.02652	**l_277**	0.04028	-0.10311
Floral rose, m	**m_135**	-0.36165	0.10199	**m_277**	0.37388	0.08338

For sample code_135 the factor value ranges between -0.30948 to 0.43533. Here we note the factors that negatively contribute to the receipt of the volatile components coded h, j, k, which are freshly cut grass, wet wood and residual. The positive factors are b, d, f, namely vanilla fruity, lemon floral and green fruit floral.
For sample code_277, the values are between -0.48269 and 0.44861. Among the positive influences, e-the floral fresh elder flavor is remarkable. The values that negatively influence the general composition of the flavor are: i, j, a, b, c, d, j, l.
At sample code_389, the factor values range between -0.29636 and 0.52016. The flavor descriptors with negative influences on the aromatic profile are: h, i, j, k, a, c, f, g, h. The other have a positive influence and the m descriptor, the floral rose aroma, stands out.
The factors that influence the sensory profile of sample code_453 have values ranging from -0.35455 to 0.56099. The negative influences are given by h, j, a, b, c, e, f, g and l. Among the positive ones, the highest significance lays with k PC2, the wet wood flavor.
The graphic representation is the simultaneous relationship between parameters with the detection of possible influence groups. Using the technique of differentiation and

similarity between the results, it can be seen which flavor descriptors have been highlighted. A mean value of the results for each sample and each panelist was made.

Table 2. *Values of volatile components and significance for PC, PC1 and PC2 for 389 and 453 sample*

Flavor descriptors	PC1_389		PC2_389	PC1_453		PC2_453
	Code	Loading	Loading	Code	Loading	Loading
Flowery sweet, a	**a_389**	0.33316	-0.17389	**a_453**	0.28879	-0.10275
Fruity-vanilla, b	**b_389**	0.34237	0.29442	**b_453**	0.18007	-0.15951
Flowery elder leaves green, c	**c_389**	0.40649	-0.23636	**c_453**	0.35455	-0.01681
Floral lemon, d	**d_389**	0.44389	0.13606	**d_453**	0.40786	0.21822
Flowery fresh elderflower, e	**e_389**	0.37721	0.10591	**e_453**	0.34192	-0.06202
Green fruits, f	**f_389**	0.2638	-0.05336	**f_453**	0.30762	-0.13669
Floral dry elderberry, g	**g_389**	0.18389	-0.09129	**g_453**	0.18751	-0.01177
Freshly cut grass, h	**h_389**	-0.0943	-0.25752	**h_453**	-0.00112	0.46961
Garlic, i	**i_389**	-0.2384	0.03128	**i_453**	0.17641	0.44249
Residual, j	**j_389**	-0.20291	-0.32016	**j_453**	-0.06192	0.36162
Wet wood, k	**k_389**	-0.16923	0.44322	**k_453**	0.03159	0.56099
Licorice, l	**l_389**	0.07188	0.38665	**l_453**	0.37042	-0.16386
Floral rose, m	**m_389**	0.15204	0.52016	**m_453**	0.41502	0.06904

In Figure 2A, volatile components influencing the flavor of the product are: b_135 (fructate-vanilla); f_135 (green fruits), g_135 (dry floral flora) with lower values c_135 (flowery-elder leaves green) and m_135 (floral-rose). The coded descriptors j_135 (residual), k_135 (wet wood) have a negative influence on the aromatic profile, h_135 (freshly cut grass) is very close to 0. From PC2 a_135 (floral-sweet) and c_135 is positive influence and i_135 (garlic) is very close to 0. They correlate very well f and g that are very close, so they correlate very well.

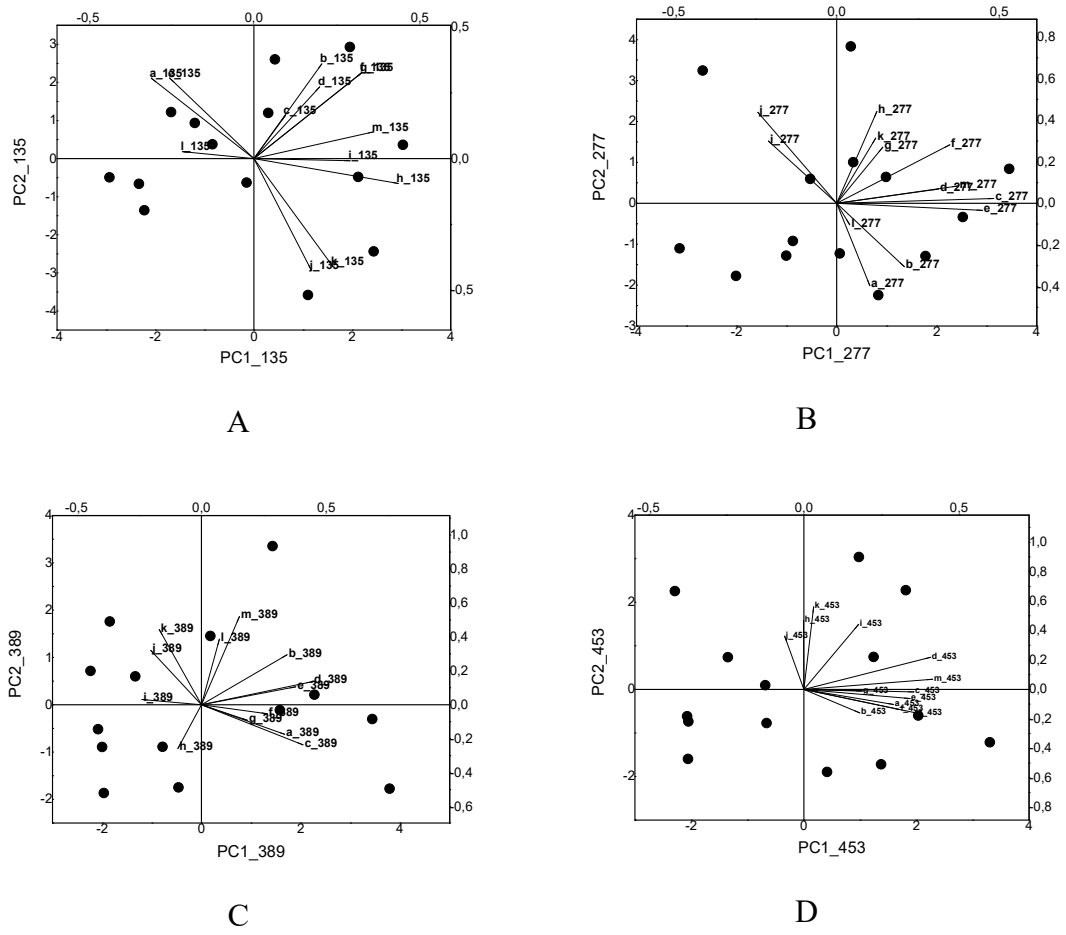
In Figure 2B volatile components influencing the flavor of the product are: h_277 (freshly cut grass); f_277 (green fruit), g_277 (floral dry elderberry), with lower values d_277(floral-lemon) and c_277 (flowery-elder leaves green), very close to 0, c_277 and e_277(flowery fresh elderflower). Descriptors coded a_277 (floral-sweet), b_277 (fructate-vanilla), have a negative influence on the aromatic profile, l_277 (wet wood) is very close to 0.

In Figure 2C the volatile components influencing the flavor of the product are: m_389 (floral-roses), b_389 (fruit-vanilla), d_389 (lemon floral), e_389 (flowery fresh elderflower) with lower and close spheres of influence c_389 and a_389 (floral-sweet), g_389 (floral dry elderberry) and f_389 (green fruits) very close to 0.

Descriptors coded h_389 (freshly cut grass), k_389 (wet wood), j_389 (residual) have a negative influence on the aromatic profile, i_389 (garlic) is very close to 0. From PC2 a_389 (floral-sweet) and c_389 (floral green elder) have positive influence and i_135 (garlic) is very close to 0.

In a Figure 2D volatile components influencing the flavor of the product are grouped into the influence register, contributing almost all to the enhancement of the flavor.

Thus, one can notice: d_453 (floral-lemon), k_453 (wet wood), f_453 (green fruits), h_453 (freshly cut grass) with m_453 (floral-rose).
Very close to 0, with lower values and close spheres g_453 (floral dry elderberry), c_453 (green floral shock), e_453 (fresh floral shock), a_453 (sweet floral), f_453 (green fruit), b_453 (vanilla fruit), i_453 (garlic).
Thus, according to the literature [5, 16, 19, 20 – 23], the flavor descriptors are associated with certain chemical components. They are present in the elder flower extracts and are the flavor precursors that can be found in the studied samples. Fragrances resulting from fermentation and the applied technology appear alongside these.
Quantities determined by advanced dynamic headspace sampling techniques [5] for collecting volatile components are present in the concentrated extract. Diluted substances that provide the flavor are present in the samples under study.
Here is how the aromatic profile of the samples that were the subject of this study was outlined.
The traditional elder flower juice, prepared with fermentation produced mainly by yeast (135) contains in its aromatic profile the fruity flavor, vanilla, which bear great influence, and, according to the above-mentioned literature, is given by pentanal. This is found in the elder flower extract in quantity of 246 $ng \cdot mL^{-1}$ [13].
The direction of flavor development is towards the floral lemon aroma given by α-terpinene (0.4-33.5 $ng \cdot mL^{-1}$) [10], limonene (1.6-32.5 $ng \cdot mL^{-1}$) [13], green fruit given by (Z)-3-hexenyl (max 4.1 $ng \cdot mL^{-1}$) [13], dried elder flowers given by linalool oxide pyranoid form [16], rose given by *cis*- rose oxide (1.2-2320 $ng \cdot mL^{-1}$) [13], freshly cut grass, which is given by hexanol, hexanal, (E)-3 hexen 1-ol, E-E-2.4 heptadienal, (E) -2 octenal (7.5 $ng \cdot mL^{-1}$ maxim) [13].
In the aromatic profile of the elder flower juice fermented with yeast and preserved by pasteurization (277), as in sample 135, the aroma of freshly cut grass, green fruits, dry elder and more recently fresh elder given by linalool oxide has a great influence.
The floral rose aroma is given by *cis*-rose oxide and also by benzyl alcohol (2.6-51.6 $ng \cdot mL^{-1}$) [13] for yeastless elder flower juice (389).
Also the aroma of vanilla, lemon, green fruits and fresh elder is also felt at a lower intensity as in samples 135 and 277.
For the newly created product - *"elder flower compote"* (453) the following flavors predominate: lemon, wet wood given by terpinen-4ol (maximum 4.5 $ng \cdot mL^{-1}$ extract, [13], green fruits as in samples 135, 277, 389, freshly cut grass as in sample 135 and rose as in sample 389.
The applied technology as described in the schemes of Figure 1B may influence the aromatic profile of the products. It is noticed that for the newly obtained product, the elder flower compote, the aroma has developed during storage and due to the thermal treatment.



A B C D

Figure 2. *Bioplot area of PC1and PC2, permuted, of the components of the aromatic profile for coded samples: 135 (A); 277 (B); 389 (C); 453 (D)*

Being closed in the packaging unit, the intensity of the flavor components was higher but less persistent (Table 3 and 4). The fermentation conditions in open containers and the aeration of the sample during filtration and dosing for the thermal treatment led to flavor loss and decrease of intensity of the aromatic profile descriptors (the general impression at sample code 277 is 1.87 and at sample code 389 is 1.57) (Table 4).

The fermented and freshly consumed elder flower juice had the highest score to the general impression (sample code 135 is 2), and the second place in the preferences' list is occupied by the compote with a score of 2.14.

In the second part of this study, in another paper, the physicochemical and technological characteristics of these beverages will be presented.

Table 3. *The length of the flavor, as duration (seconds) after tasting*

No. panel	Sample Cod			
	135	**277**	**389**	**453**
1	short[3]	short	short	long
2	moderate[2]	long	long	long
3	long[1]	moderate	moderate	short
4	long	short	moderate	short
5	long	long	long	moderate
6	moderate	short	short	moderate
7	moderate	moderate	short	long
8	long	short	moderate	short
9	moderate	moderate	long	moderate
10	long	moderate	moderate	long
11	long	moderate	long	short
12	short	long	moderate	long
13	short	long	long	long
14	short	long	long	moderate

[1] 30 seconds; [2]15 seconds; [3]10 seconds

Table 4. *Overall impression (points) for the investigated samples of "aromatic profile method"*

No. panel	Sample code			
	135	**277**	**389**	**453**
1	2	2	1	2
2	3	2	3	3
3	3	2	1	1
4	3	2	2	2
5	3	2	1	2
6	3	1	1	2
7	2	1	1	3
8	3	2	1	3
9	2	2	1	2
10	3	2	2	1
11	3	2	1	2
12	1	1	2	2
13	2	2	3	3
14	3	3	2	2
$\bar{X} = \frac{\sum_{i=1}^{n} x_i}{n}$	2.57	1.85	1.57	2.14

1 - weak; 2 - medium; 3 - high; n = 14

CONCLUSION

Despite of the fact that only water, sugar, lemon and fresh elder flowers are used, by permuting some stages of the technological schemes, assortments of natural drinks can be obtained which are preferred. The factors influencing the aromatic profile of the analyzed samples of this study were identified as: the recipe, the preservation technique, the management of the fermentation and filtration process, the selection and training of the team of tasters. Thus, the flavor components that were present in all the studied samples and felt at high intensity were: fruity vanilla, lemon floral, green fruits, dry elder, rose, freshly cut grass and wet wood. It has been noticed that the newly obtained product, that is, *"the elder flower compote*" has the flavors closed in the packaging unit, being noted at maximum intensity at the time of consumption. The most intensive fragrance descriptor was the floral rose one. For the classical fermented "elder flower juice", the most intensive flavor was the fruity vanilla and lemon. The flavor of fresh elder flowers has a great influence in the aromatic profile of the elder flower juice preserved by pasteurization and in the case of the yeastless one; the greatest influence lays with the floral rose aroma. The overall impression of the sensory profile for the elder flower compote is 2.14 in the second place after the classic *"elder flower juice*" that has a score of 2.57. The duration of the persistence of the fragrance in the elder flower compote is also on the second position, after the traditional elder flower juice.

REFERENCES

1. Ho, G.T.T., Zou, Y.F., Aslaksen, T.H., Wangensteen, H., Barsett, H.: Department, Structural characterization of bioactive pectic polysaccharides from elderflowers (*Sambuci flos*), *Carbohydrate Polymers*, **2016**, **135**, 128-137;
2. Sidor, A., Gramza-Michałowska, A.: Advanced research on the antioxidant and health benefit of elderberry (*Sambucus nigra*) in food – a review**,** *Journal of Functional Foods*, **2015**, **18**, 941-958;
3. Schumacher, F.: *Schweiz Z Obst- und Weinbau,* **1983**, **119**, 551-560;
4. Gotfried, R.: Designer drinks. Elderberry flower extract, *Food Marketing Technol*, **1993**, **7 (3)**, 9-10;
5. Jørgensen, U., Hansen, M., Christensen, L.P., Jensen, K., Kaack, K.: Olfactory and quantitative analysis of aroma compounds in elder flower (*Sambucus nigra L.*) drink processed from five cultivars, *Journal of Agricultural and Food Chemistry*, **2000**, **48**, 2376-2383;
6. Atkinson, M.D., Atkinson, E.: *Sambucus nigra* L. *Journal of Ecology*, **2002**, **90**, 895-923;
7. ELD 1: http://www.sacredearth.com/ethnobotany/plantprofiles/elder.php, Elder in profile, accessed August 11, **2017;**
8. Committe on Herbal Medicinal Products (CHMP) *Sambucus nigra* L., flos. London: *European Medicines Agency Evaluation of Medicines for Human Use***, 2008**;
9. Senica, M., Stampar, F.,Veberic, R., Mikulic-Petkovsek, M.: Processed elderberry (*Sambucus nigra* L.) products: A beneficial or harmful food alternative?, *LWT - Food Science and Technology*, **2016**, **72**, 182-188;
10. Młynarczyk, K., Walkowiak-Tomczak, D.: Bioactive properties of elderflowers (*Sambucus nigra* L.), *World Scientific News*, **2017**, **73 (2),** 115-119;
11. Kaack, K., Christensen, L.P., Dirker, A.J.: German Federal Republic Patent, DE 4119352C1, **1992**;
12. Farr, S.: *Food Manufacture*, **1994**, **69**, 29-30;
13. Kaack, K., Christensen, L.P., Hughes, M., Eder, R.: The relationship between sensory quality and volatile compounds in raw juice processed from elderberries (Sambucus nigra L.), *European Food Research and Technology*, **2005**, **221**, 244-254;

14. Mikulic-Petkovsek, M., Ivancic, A., Schmitzer, V., Veberic, R, Stampar, F.: Comparison of major taste compounds and antioxidative properties of fruits and flowers of different *Sambucus* species and interspecific hybrids, *Food Chemistry*, **2016**, 134-140;
15. Salvador, A.C., Rudnitskaya, A., Silvestre, A.J.D., Rocha. S.M.: Metabolomic-based strategy for fingerprinting of *Sambucus nigra* L. Berry volatile terpenoids and norisoprenoids: Influence of ripening and cultivar, *Journal of Agricultural and Food Chemistry*, **2016**, **64** (26), 5428-5438;
16. Kaack, K., Christensen, L.P., Hughes, M., Eder, R.: The relationship between sensory quality and volatile compounds in raw juice processed from elderberries (*Sambucus nigra* L.), *European Food Research and Technology*, **2005**, **221**, 244-254;
17. Pfannhauser, W.: Analyse flüchtiger Inhaltsstoffe des Holunders, *Dtsch Lebensm-Rdsch*, **1986**, **82**, 289-293;
18. Poll, L., Lewis, M.J.: Volatile components of elderberry juice, *Lebensm-Wiss u-Technol*, **1986**, **19**, 258-262;
19. Jensen, K., Christensen, L.P., Hansen, M., Jørgensen,U., Kaack, K.: Olfactory and quantitative analysis of volatiles in elderberry (*Sambucus nigra* L.) juice processed from seven cultivars. *Journal of the Science of Food and Agriculture*, **2001**, **81**, 237-244;
20. Bauer, K., Garbe, D., Surburg, H.: Common fragrance and flavor materials: Preparation properties and uses, *Wiley, New York*, **1997**, 278;
21. Curtis, T., Wiliams, D.G.: Introduction to perfumery, *Ellis Horwood*, *New York*, **1994;**
22. *Aldrich Chemical Co. Flavours and Fragrances*, Aldrich Chemical Co. Inc., Milwaukee, WI, **1996**;
23. Acree, T., Arn, H.: Flavournet: www.nysaes.cornell, edu/flavournet/index.html, **1997**;
24. Burdock, G.A.: Fenaroli's Handbook of Flavor Ingredients, 4th edition, *CRC Press*, *Boca Raton*, **2002**.