Cluster Analyses of Technological Parameters of the Cherry Juice

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Abstract*- Grouping varieties by similar technological and organoleptic indicators of clusters and associations can prevent losses for million euro, as can consumer confidence in the trademark. For example, it is known that varieties such as Bing, Stella, Lapins have excellent technological and organoleptic characteristics, which makes them interchangeable, and in the absence of supplies of certain varieties, they can be replaced by others, with similar taste or color and similar nutrition composition, with which they are found in one cluster. In production plants for the processing of fruits and vegetables, different products are produced, for example, juices with certain taste and nutritional qualities, exactly with a certain pleasant color and consistency. The mixing of varieties from different clusters can lead to a sharp amendment of the approved recipe approved by the food agencies of the respective countries, corresponding to the marketing studies, the HACCP food safety system, etc. Similarly, technologists and laboratory technicians in enterprises should be careful when making adjustments during the technological process and keep in mind, that the pH adjustment, for example, can also change the other parameters of the cluster such as TDS, Salt, etc. On the other hand, changing the sugar content will not affect these parameters, but will abruptly change the ratio Brix / pH as well as the other ratios in the cluster, which will directly affect the taste, already determined precisely by ratio Brix / pH.

***Key words:* cluster analyses, statistics, fruit technology, cherry juice.**

I. INTRODUCTION

Cherry is an important raw material for the food industry and cooking in terms of fruit. It is one of the main raw materials in a wide range of productions in the food industry. It is used for producing of cloudy and clear juice, syrups, juice concentrates, nectars, purees, wine, vinegar, cider, malic acid, fruit flours, dried fruits, compotes, marmalades, smoothies, and more. It is an indispensable fruit for direct consumption, canning, as well as in cooking and confectionery for various dishes.

The aim of the study is to be analyzed 33 of the popular charry varieties, grown by the Institute of Agriculture in town of Kyustendil, Bulgaria for their main technological parameters, in view of their safety for the population and the possibilities for their use as raw material for the production of cold-pressed juices in the canning industry.

II. LITERATURE REVIEW

There are number of studies related with statistics of chemical parameters of the cherry juice as [1,2,3]. Data about the technological parameters of the cherries and the cherry juice published [4,5,6]. Biochemical studies and study of different varieties presented [7,8,9]. High number of scientists worked on cherry fruits and trees different topics than the present study, using cluster analyses and statistical methods [10].

III. METHODS

The aim of the study is to apply the statistical method Cluster analysis for the interpretation of technological data from juice studies of 33 cherry varieties. Digital instruments were used as follow: Brix refractometer “MA871” to measure the total sugar content by Brix (%),"SensoDirect 150" apparatus and "Waterproof IP57" tester for determination of total acidity (pH), electrical conductivity (EC, µS), total dissolved solids (TDS, ppm), total salt content (Salt, ppm) and ORP/Redox meter was used for the measurement of the Eh, (mV) of the juices. The juices were produced by the cold-pressing method, using 3 atm. pressure of the press at 20°C. Total 30 measurements were performed for each cherry variety. The statistical processing of the data was performed by using computer application XLStat. Studied technological parameters and methodology are selected according to the *Bulgarian State Gazette* No 100 (2013) [11].

IV. RESULTS AND DISCUSSION

Table 1 presents data, summarized by 4 years measurements of 33 varieties of cherry fruits, sweet and sour cherries. Ratios between different technological parameters are also presented. [1] published data that different parameters are depended each other as the ratios of all varieties have similar rates. Because of this reason we decided to process the data for clustering to discover some invisible relation between technological parameters and cherry varieties.

Table 1. Measured technological parameters of the cherry juices by varieties.

Cherry Variety	Juice Brix-Total Sugar, %	Juice pH-Total Acidity	Juice ORP-Oxidation Reduction Potential, Eh (mV)	Juice Conductivity EC, mS/Sec.	Juice TDS-Total Dissolved Solids, ppt	Juice Salt, ppt	Juice Ratio Brix/pH	Juice Ratio EC/TDS	Juice Ratio EC/Salt	Juice Ratio TDS/Salt
Bing / Hybrid 2	14,80	3,54	378	2,26	1,12	1,17	4,18	2,03	1,93	0,95
Bing / PHL 84	15,00	3,6	362	2,33	1,17	1,04	4,17	1,99	2,24	1,13
Bing / MK-M9	16,70	3,76	377	2,15	1,05	1,06	4,44	2,05	2,03	0,99
Bulgarian Hrushtyalka	16,60	3,49	369	2,67	1,34	1,36	4,76	1,99	1,96	0,99
Drogan Gelbe	14,40	3,65	359	2,30	1,14	1,16	3,95	2,02	1,98	0,98
Erdi Botermo (sour cherry)	15,90	3,45	241	1,85	0,89	0,92	4,61	2,07	2,00	0,97
Kozereska	16,80	3,52	364	1,29	0,69	0,68	4,77	1,88	1,90	1,01
Lapins / CAB 6P	16,40	3,6	359	2,40	1,19	1,29	4,56	2,02	1,86	0,92
Lapins / Alkavo	13,90	3,62	373	2,24	1,11	1,13	3,84	2,02	1,98	0,98
Lapins / Gisela 5	14,70	3,72	381	2,20	1,10	1,10	3,95	2,00	2,00	1,00
Lapins / Gisela 6	13,80	3,77	375	2,00	1,00	1,02	3,66	2,00	1,96	0,98
Lapins / F 12/1	14,60	3,7	387	1,99	1,09	1,06	3,95	1,82	1,87	1,03
Lapins / MaxMa 14	15,60	3,64	347	2,82	1,40	1,41	4,29	2,01	2,00	0,99
Victory Crimea (Pobeda Krimska)	15,10	3,71	380	2,83	1,41	1,43	4,07	2,01	1,98	0,99
Rainier / Max	18,40	3,6	390	2,24	1,11	1,11	2,24	2,02	2,02	1,00
Stella	15,70	3,52	364	2,33	1,16	1,17	4,46	2,01	1,99	0,99
Summit / Alkavo	14,90	3,64	377	2,01	1,01	1,03	4,09	1,99	1,95	0,98
Summit / CAP	16,90	3,66	382	2,17	1,07	1,21	4,62	2,03	1,79	0,88
Summit / Gisela 5	13,40	3,55	377	2,67	1,34	1,34	3,77	1,99	1,99	1,00

Summit / F 12/1	13,80	3,45	394	2,61	1,29	1,30	4,00	2,02	2,01	0,99
Simmit / Gizela 6	16,70	3,65	401	2,22	1,12	1,21	4,58	1,98	1,83	0,93
Summit / Max	14,90	3,52	343	2,37	1,14	1,14	4,23	2,08	2,08	1,00
Summit / Maxma 14	15,40	3,69	373	2,25	1,22	1,83	4,17	1,84	1,23	0,67
Summit / MaxMA 60	14,50	3, 62	394	2,10	1,06	1,07	4,01	1,98	1,96	0,99
Sunburst	14,30	3,69	239	2,15	1,10	1,21	3,88	1,95	1,78	0,91
Van / Karamy	19,30	3,43	366	2,08	1,04	1,05	5,63	2,00	1,98	0,99
Van/Max	14,90	3,39	392	2,61	1,25	1,26	4,40	2,09	2,07	0,99
Van/P1 (10-18 tree)	17,40	3,57	398	2,22	1,08	1,09	4,87	2,06	2,04	0,99
Van / SL-64	15,50	3,48	377	2,99	1,49	1,51	4,45	2,01	1,98	0,99
Van / Vladimir	16,70	3,45	387	2,04	1,03	1,03	4,84	1,98	1,98	1,00
Vasileva Hrushtyalka	19,30	3,54	375	2,02	1,06	1,07	5,45	1,91	1,89	0,99

Using the cluster analysis were determined similarities of the measurement data for cherry juice technological parameters by variety. The data collected in this way are grouped into clusters of similar, very close, common origin technological parameters or those that are interdependent, influenced by the same factors and change in groups when changing any of the indicators. Two types of clusters have been calculated – grouping by cherry varieties with the same or close technological indicators (Fig. 1, Table 2) and grouping of indicators that are found in connection and interaction (Fig. 3, Table 3). The individual clusters are separated by associations.

Fig. 1 presentc the dendrogram of the Agglomerative hierarchical clustering (AHC), which group the studied data into clusters, each of them is divided of associations. Associations are varieties with almost equal technological parameters, or they have one origin, or they relate each other. We may recognize from these figures the following associations between the cherry varieties:

Cluster C1:

Association 1: Van/Vladimir-all varieties to Rainier Max, which parameters are related each other to a lesser or greater extent.

Cluster C2:

-Association 1: Sunburst, Erdil Botermo-Vasileva Hryushtyalka-Van/Karamy-Kozerska, which means that these varieties have very different technological parameters than the cherry varieties of cluster C1.

Fig. 3 presents the dendrogram of the Agglomerative hierarchical clustering (AHC) of different technological parameters of the cherry varieties:

Cluster C1:

Association 1: Brix-Brix/pH-EC/TDS-EC/Salt-TDS/Salt

Cluster C2: pH-Eh-Salt-EC-TDS

For comparison dendrograms of dissimilarity were added between the individual cultivars Fig. 2 and between the individual measured technological parameters of cherry juices Fig. 4. This makes it clearer which varieties are significantly different from the others and which technological parameters are largely unaffected by others and difficult to bind to them. For example, Sunburst and Erbil Botermo varieties are clearly distinguished. Care should be taken with these varieties in cherry processing and cherry juice production plants, especially for cold-pressed juices, where juice corrections can only be made by mixing different cherry varieties. From Fig. 4 it is seen that the ORP-Oxidation Reduction Potential, Eh (mV) is a highly independent parameter which is hardly influenced by the others and obviously has another origin and does not change easily when changing the remaining technological parameters of the juice.

Table 2. Agglomerative hierarchical clustering (AHC) / Number of clusters = 2:

Summary statistics
similarity:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
X1	31	0	31	3,390	3,770	3,588	0,102
X2	31	0	31	239,000	401,000	367,129	36,629
X3	31	0	31	1,287	2,990	2,271	0,333
X4	31	0	31	0,686	1,490	1,138	0,158
X5	31	0	31	0,677	1,830	1,176	0,204
X6	31	0	31	2,240	5,627	4,286	0,594
X7	31	0	31	1,822	2,088	1,995	0,061
X8	31	0	31	1,230	2,240	1,944	0,159
X9	31	0	31	0,667	1,125	0,974	0,070

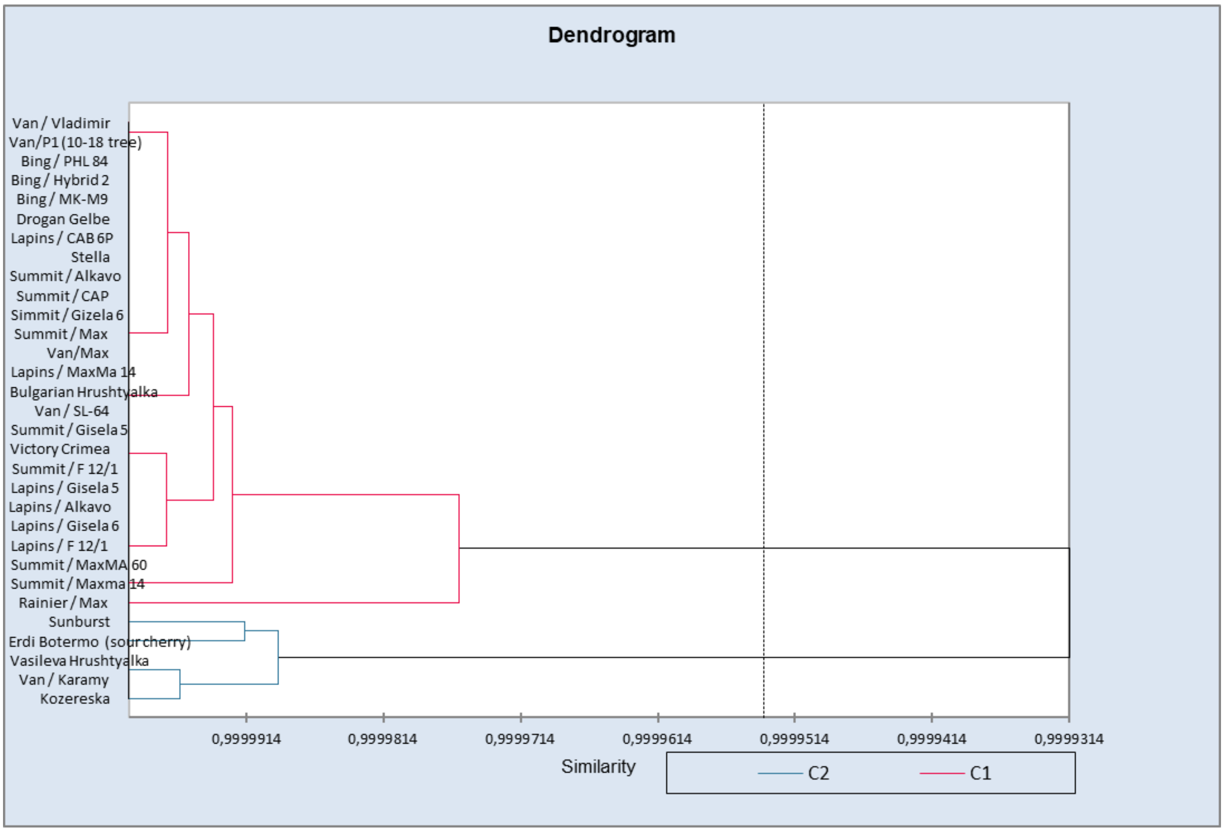

Fig. 1 Dendrogram of similarity between different cherry varieties. Dotted line shows the coefficient of correlation.

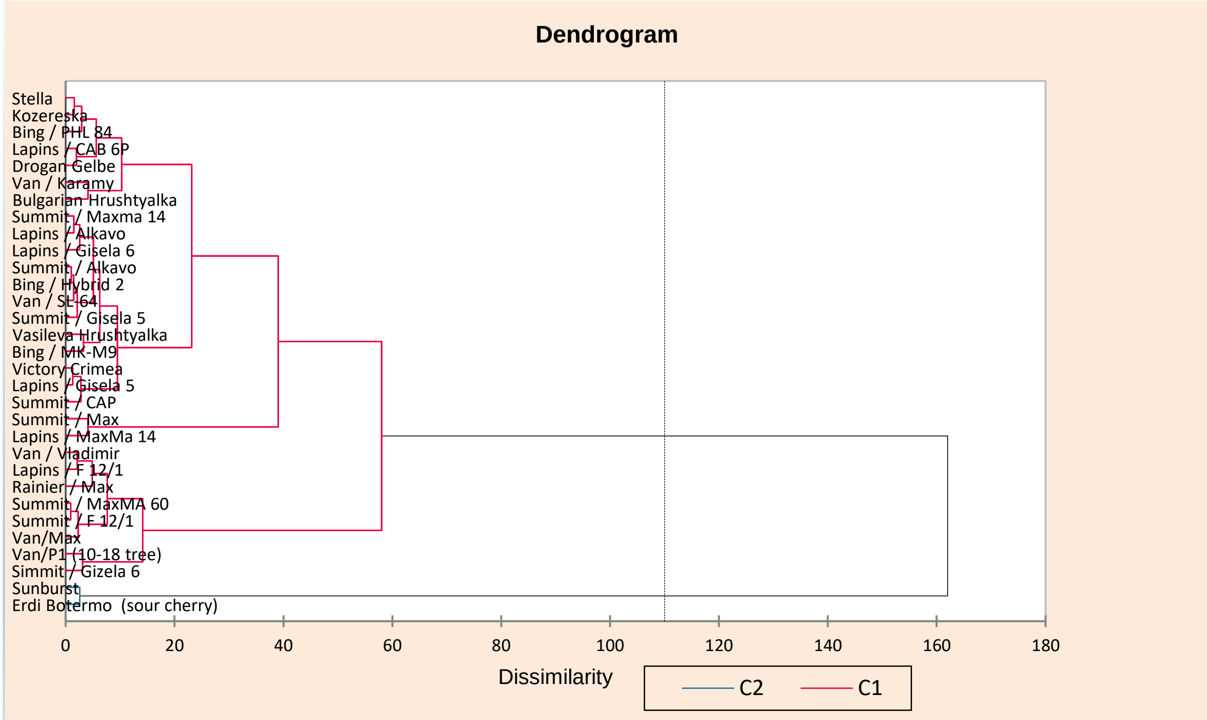

Fig. 2 Dendrogram of dissimilarity between different cherry varieties.

Table 3. Agglomerative hierarchical clustering (AHC) / Number of clusters = 2:

Summary statistics similarity:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
X1	10	0	10	1,000	378,000	41,003	118,480
X2	10	0	10	1,040	362,000	39,466	113,403
X3	10	0	10	1,000	377,000	41,124	118,108
X4	10	0	10	1,000	369,000	40,417	115,545
X5	10	0	10	1,000	359,000	39,060	112,486
X6	10	0	10	0,893	241,000	27,370	75,196
X7	10	0	10	0,677	364,000	39,653	114,066
X8	10	0	10	1,000	359,000	39,331	112,414
X9	10	0	10	1,000	373,000	40,384	116,932
X10	10	0	10	1,000	381,000	41,277	119,436
X11	10	0	10	0,980	375,000	40,519	117,587
X12	10	0	10	1,028	387,000	41,811	121,355
X13	10	0	10	0,993	347,000	38,116	108,616
X14	10	0	10	0,986	380,000	41,352	119,061
X15	10	0	10	1,000	390,000	42,374	122,256
X16	10	0	10	0,991	364,000	39,733	114,020
X17	10	0	10	0,981	377,000	40,861	118,181
X18	10	0	10	0,884	382,000	41,633	119,688
X19	10	0	10	1,000	377,000	40,806	118,182
X20	10	0	10	0,992	394,000	42,547	123,545
X21	10	0	10	0,926	401,000	43,522	125,693
X22	10	0	10	1,000	343,000	37,546	107,405
X23	10	0	10	0,667	373,000	40,530	116,898

X24	10	0	10	0,991	394,000	42,529	123,560
X25	10	0	10	0,909	239,000	26,997	74,596
X26	10	0	10	0,990	366,000	40,350	114,555
X27	10	0	10	0,992	392,000	42,496	122,872
X28	10	0	10	0,991	398,000	43,332	124,715
X29	10	0	10	0,987	377,000	41,140	118,086
X30	10	0	10	1,000	387,000	42,105	121,276
X31	10	0	10	0,991	375,000	41,223	117,408

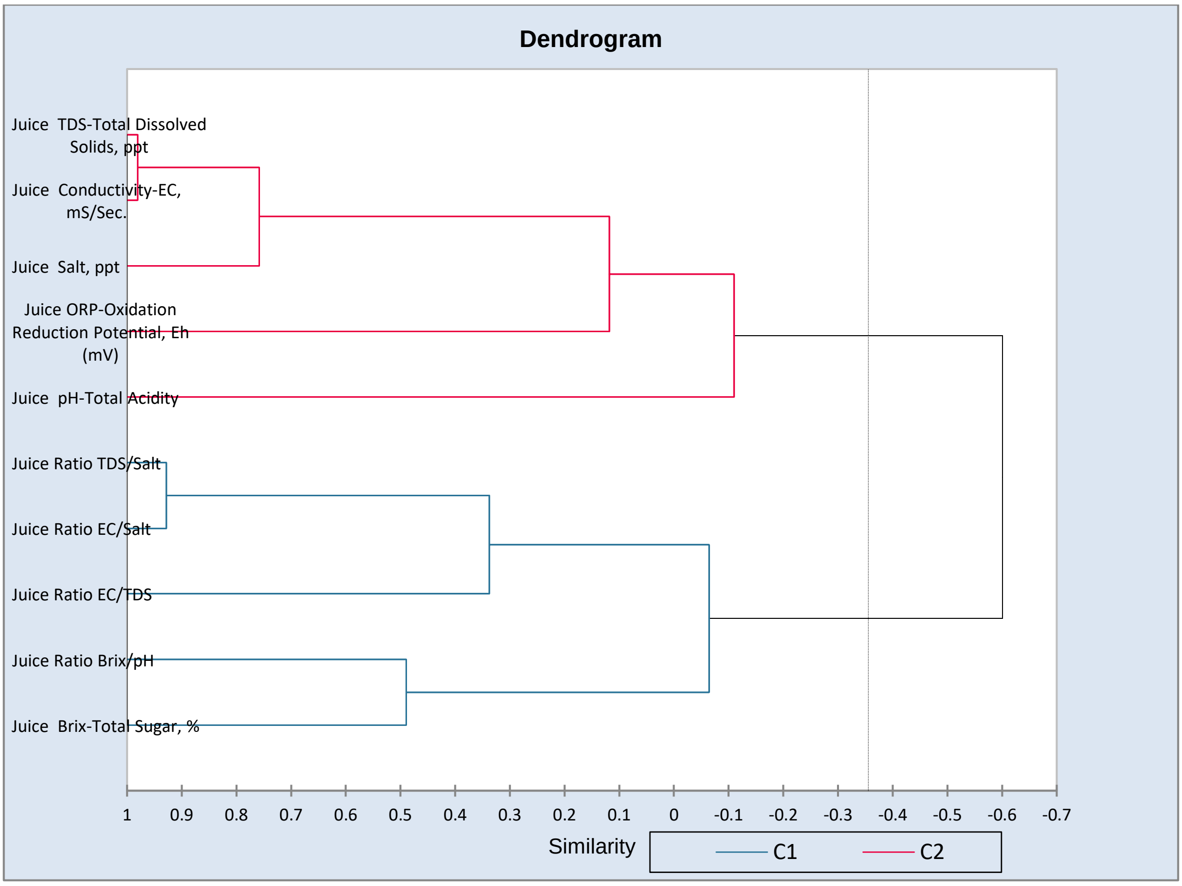

Fig.3 Dendrogram of the Agglomerative hierarchical clustering (AHC) of similarity of different technological parameters of the cherry varieties:

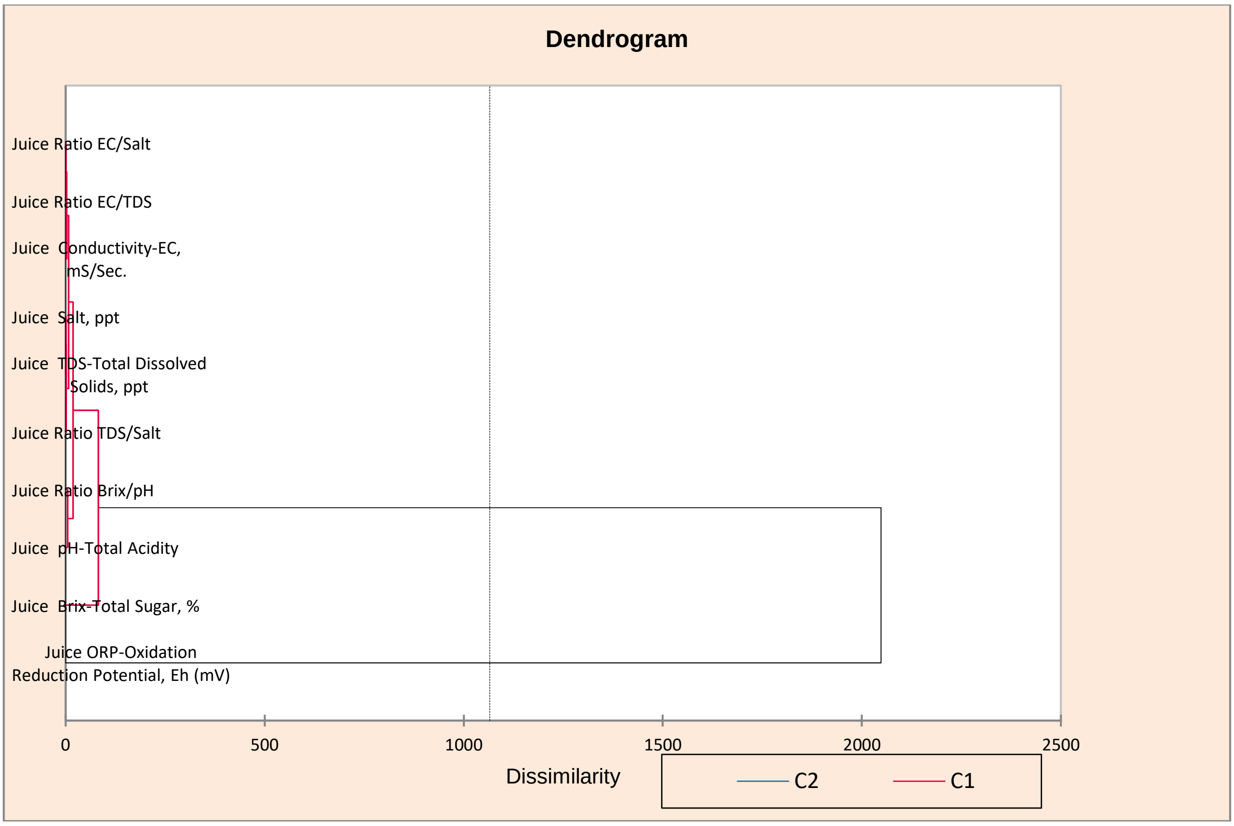

Fig.4 Dendrogram of the Agglomerative hierarchical clustering (AHC) of dissimilarity of different technological parameters of the cherry varieties:

V. CONCLUSION

The most important conclusion of this study is that cluster analysis is extremely useful for processing data of technological parameters of fruits and cherries in particular in processing plants. Grouping varieties by similar technological and organoleptic indicators of clusters and associations can prevent losses for million euro, as can consumer confidence in the trademark. For example, it is known that varieties such as Bing, Stella, Lapins have excellent technological and organoleptic characteristics, which makes them interchangeable, and in the absence of supplies of certain varieties, they can be replaced by others, with similar taste or color and similar nutrition composition, with which they are found in one cluster. In production plants for the processing of fruits and vegetables, different products are produced, for example, juices with certain taste and nutritional qualities, exactly with a certain pleasant color and consistency. The mixing of varieties from different clusters can lead to a sharp amendment of the approved recipe approved by the food agencies of the respective countries, corresponding to the marketing studies, the HACCP food safety system, etc. Similarly, technologists and laboratory technicians in enterprises should be careful when making adjustments during the technological process and keep in mind, that the pH adjustment, for example, can also change the other parameters of the cluster such as TDS, Salt, etc. On the other hand, changing the sugar content will not affect these parameters, but will abruptly change the ratio Brix / pH as well as the other ratios in the cluster, which will directly affect the taste, already determined precisely by ratio Brix / pH. The addition of soluble solids in the nutritional consistency will lead to a change in electrical conductivity EC, which in turn determines the sharpening of some basic taste perceptions of the mucous membrane in man.

REFERENCES:

[1] D. Sotirov, A. Sotirov and S. Dimitrova. “Technological Parameters of Some Cherry Varieties,” *Journal of Mountain Agriculture on the Balkans (JMAB), Research Institute of Mountain Stockbreeding and Agriculture-Troyan, Agricultural Academy of Bulgaria, 2023, in press.*

[2] R. Preti, R. Bernacchia and V. Giuliana, “Chemometric evaluation of biogenic amines in commercial fruit juices,” European Food Research and Technology, vol. 242, 2016, 10.1007/s00217-016-2701-5.

[3] S. Benedetti, A. Spinardi, I. Mignani and S. Buratti, S., “Non-destructive evaluation of sweet cherry (Prunus avium L.) ripening using an electronic nose,” Ital. J. Food Sci., vol., 22., 2010, pp. 299-306.

[4] V. Georgiev, M. Borovinova and A. Koleva, “Sweet Cherry*”*, Ed. House “Sofia-Zemizdat”, 2001, pp. 352 pp (in Bg).
[5] V. Silva, S. Pereira, A. Vilela, E. Bacelar, F. Guedes C. Ribeiro, A. Silva and B. Gonçalves, “Preliminary Insights in Sensory Profile of Sweet Cherries”. Foods, 13 March 2021, vol. 10(3):612.
[6] E. Szpadzik, T. Krupa, K. Molska-Kawulok and S. Przybyłko, “Fruit Quality and Contents of Some Bioactive Compounds in Selected Czech Sweet Cherry (*Prunus avium* L.) Cultivars under Conditions of Central Poland,” Agriculture 12(11), 1859; https://doi.org/10.3390/agriculture12111859
[7] G. Upadysheva, S. Motyleva, I. Kulikov, S. Medvedev and M. Mertvishcheva, “Biochemical composition of sweet cherry (Prynus avium L.) fruit depending on the scion-stock combinations,” Potravinarstvo Slovak Journal of Food Sciences, vol. 12, no. 1, pp. 533-538, 2018.
[8] V. Usenik, N. Fajt, M. Mikulic-Petkovsek, A. Slatnar, F. Stampar and R. Veberic, “Sweet Cherry Pomological and Biochemical Characteristics Influenced by Rootstock,” *J. Agric. Food Chem.*, 2010, 58, 8.
[9] M. Vavoura, A. Badeka, S. Kontakos and M.G.Kontominas, “Characterization of four popular sweet cherry cultivars grown in Greece by volatile compound and physicochemical data analysis and sensory evaluation,”*Molecules*. 2015 Jan 26;20(2):1922-40. doi: 10.3390/molecules20021922. PMID: 25629454; PMCID: PMC6272425.
[10] L. Hahn, C. Basso, J. Moura-Bueno, L. Carlos Argenta, M. Toselli, C. Carranca, M. Rech, I. Schneider Hahn and G. Brunetto, “Yield Prediction Models for ‘Royal Gala’ and ‘Fuji Suprema’ Apple Varieties Cultivated under a Subtropical Climate,” Agronomy 2023, vol. 13, pp. 514.
[11] “Bulgarian Ordinance on the requirements for fruit juices and some similar products intended for human consumption,” Bulgarian State Gazette No 100, 2013.