Using of Multivariate Analysis for Evaluation of Lactic Acid Fermented Cabbage Juices

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The lactic acid fermented cabbage juices were inoculated by *Lactobacillus plantarum* 92H at concentration 2.2×10^8 CFU cm^{-3} of juice. At the end of fermentation, the samples contained 14.49 g kg^{-1} of organic acids and 27.30 mg kg^{-1} of nitrates. The organic acids (expressed as lactic, acetic, and citric acids) were determined by capillary isotachophoresis. The suitable colour for juices was light-orange with medial turbidity. In the 72—96 h of fermentation, the juices had the most harmonic taste and flavour.

From the correlation analysis it resulted that the highest values of correlation coefficients are between total acidity and pH (−0.98) and at the assessment of taste descriptors of juices, the highest correlation between sweet and acid (−0.97) was found. Principal component analysis reduced 15 sensory descriptors to 3 independent variables, which accounted for 79.80 % of total variance and 6 analytical descriptors, which accounted for 87.10 % of total variance.

Generally, multidimensional statistical methods are discussed when more attributes or characters or variables are measured on more objects or samples, and all these quantities are observed and together evaluated. Mutual relations and connections of applicable quantities, *i.e.* variables and samples are studied based on data obtained from files.

It is common that in food analysis larger number of samples characterized by more variables are involved. Therefore, such results can be assigned to the category of multidimensional, multivariate data, which are necessary to be evaluated by multidimensional statistic methods [1].

Multidimensional analysis can be classified according to different points of view. Of significance is the method based on the dependence of variables. Multidimensional methods, such as cluster analysis, allow classification of the samples or variables to groups mutually connected together. Other methods, such as principal component analysis, enable visualizing the results (variables or samples). Also, there are many more other classifications of multidimensional statistical methods [2, 3].

Principal component analysis (PCA) is used practically in all the scientific branches. It is advantageously applied at the evaluation in the food analysis. In the recent years the PCA method has been suggested by several authors [4—8].

The manufacture of lactic acid fermented products on the basis of plant raw materials has long tradition. Lactic acid fermented vegetable juices produced mainly from cabbage, beet, carrot, celery, tomato have also gained consumer's favour. To maintain the fast and controlled fermentation of vegetable half-product, pure culture of microorganisms causing lactic acid fermentation is added to the initial raw material. The selection of lactic acid fermentation bacterial strains suitable for the production of lactic acid fermented juices is dealt with in several works [9, 10]. Strains of *Lactobacillus* genera increasing and improving flavour of juices and allowing fast decrease of pH, producing mainly lactic acid and causing utilization of nitrites and nitrates and decreasing the biogenic amines content have been studied.

The objective of this study was preparation of the cabbage juices with various concentration of *Lactobacillus plantarum* 92H. The samples were fermented during 120 h at 28 °C. In the individual time intervals, the juices were taken for the analytical (nitrites, nitrates, ammonia, organic acids, pH, total acidity) and sensory (colour, flavour, taste) determination.

The focus of the investigation was to determine suitable time of fermentation for these cabbage juices based on measured analytical and sensory data. The results of analytical and sensory parameters were evaluated by correlation analysis and principal component analysis. By PCA, the original data set was reduced to the most relevant compounds accounting for a high amount of variance of the system studied.

EXPERIMENTAL

For sensory evaluation, lactic acid fermented cabbage juices prepared from white cabbage, were used. The juices were filtered and 0.5 % NaCl was added.

The strain of microorganism was selected according to *Karovičová et al.* [11]. The *Lactobacillus plantarum* 92H was isolated from the sauerkraut and verified by biochemical tests. Initial concentration of *Lactobacillus plantarum* 92H was measured by plate counts on pour plates (LS-agar, Imuna, Šarišské Michaľany). The pour plates were incubated for 24—48 h at 37 ℃ and bacteria were counted (CFU cm^{-3}).

Measurement of pH was performed using a Präzisions-Labor-pH-Messgerät MV88 (VE Kombinat Pracitronic, Dresden).

The total acidity was determined [12] by visual titration with a 0.1 M-NaOH against phenolphthalein indicator and expressed as lactic acid.

The nitrates in the environment of sulfuric acid nitrated 3,4-xylenol to the yellow nitroxylenephenolates which were isolated from the reagent mixture by water steam and caught into the borate buffer stock. The absorption maximum of phenolates was 430 nm [13].

The ammonia from the extract of the sample was forced by potassium carbonate in the Conway vial and adsorbed by boric acid [13]. The content of the ammonia was calculated from the sulfuric acid.

The standard deviations for determination of total acidity ranged from 0.094 % to 1.078 %, for determination of ammonia from 0.02 to 0.22 mg 100 cm^{-3}, for determination of nitrates from 1.62 to 5.68 mg dm^{-3} and for determination of nitrites from 0.33 to 0.99 mg dm^{-3}. The results of analyses were calculated as average from 5 measurements.

Measurement of organic acids was realized on the isotachophoretic analyzer ZKI 01 Villa (Labeco, Spišská N. Ves) with double-line recorder TZ 4200 and conductivity detector. On the identification and determination the electrolytic system of the following composition was applied: concentration of leading electrolyte 1×10^{-2} mol dm^{-3} HCl, counter-ion 6-aminocapronic acid, pH 4.25, additive 0.1% methylhydroxyethylcellulose. Terminating electrolyte: capronic acid ($c = 5 \times 10^{-3}$ mol dm^{-3}). The samples were analyzed at the driving current of 200 μA in the preseparation column, time of analysis 11 min. Quantitative analysis was performed by calibration. Similarly was done the validation of isotachophoretic method. The standard curves showed good linearity in the range 2—10 $\times 10^{-4}$ mol dm^{-3} ($r = 0.997$). For each calibration curve, the intercept was not statistically different from zero. The relative standard deviations ranged from 1.15 to 3.01 % at all concentration levels. The recovery ranged from 89 to 96.5 % and the error of measurement from 3.5 to 11 %. The limits of detection were: 2.0 mg dm^{-3} for lactic and acetic acids and 1.62 mg dm^{-3} for citric acid.

Fermentation and Samples Used

The adjusted juices were given into the 250 cm^3 Erlenmeyer banks. Every bank represented a single sample. The juices were inoculated by night culture of lactic acid bacteria *Lactobacillus plantarum* 92H at the concentration of 2.2×10^4 CFU cm^{-3} (samples A), 2.2×10^6 CFU cm^{-3} (B), and 2.2×10^8 CFU cm^{-3} of juices (C). The banks were closed with sterilized rubber corks to ensure anaerobic conditions. The juices were fermented in the thermostat at 28 ℃ for 120 h. During fermentation, in 24-h intervals, the samples (A0, A24, ... A120; B0, B24, ... B120; C0, C24, ... C120) were taken to analytical determination and sensory evaluation.

The samples were taken during 120 h. At every sample acquisition, the samples were analytically (nitrites, nitrates, ammonia, pH, total acidity, organic acids) evaluated, after acquisition the juices were frozen and defrosted at the end of the fermentation process. For sensory evaluation, all the samples were served at the same temperature.

Assessors and Sensory Methods

Sensory evaluation of the selected fermented juices was carried out by a group of 10—14 assessors. For the sensory evaluation of juices, the sensory profile method was chosen. The total perception was split to simple sense (descriptors) that assessors according to appropriate intensity signified from minimum to maximum. The general appearance evaluation included: evaluation of colour, turbidity, and appearance. For the evaluation of general appearance, the intensity profile scale, introduced in detail by *Karovičová et al.* [14], was chosen (1 – nonsuitable, 5 – very good). The colour (light yellow with green shade, light yellow with green-brown shade, light yellow-orange, light orange-brown, orange-brown, cream orange-brown, cream orange-brown with green shade) and turbidity (no turbid, weakly turbid, soft turbid, strong turbid, turbid) were evaluated by description. For flavour evaluation of lactic acid fermented cabbage juices, the following descriptors were chosen: sweet, acid, sweet-acid, cabbage, sharp, and smelling. The taste descriptors were: sweet, salt, sweet-acid, acid, cabbage, sour, bitter, and harmonic. The harmonic taste (mixture taste) introduces taste, by which the other taste descriptors in the optimal proportions are characterized. In the linear graph, intensities of descriptors were plotted on the x axis (x axis is 100 mm long nonstructured graphic abscissa with the description of extreme points). In order to gain better orientation we, as a fast classification, introduced also the separation of nonstructured abscissa x into individual sections characterized from very weakly perceivable to very strongly perceivable, for example flavour. The individual distances were measured on the x axis; averages were calculated and presented in table form. For the evaluation of sample flavour and taste, the assessors assigned adequate intensity to every examined descriptor on the linear graph, which formed the sensory profile.

For the evaluation and visualization of results one of the multivariate statistical methods – correlation analysis and principal component analysis (PCA) was chosen. The PCA method was chosen with the assumption of using effectively the results of sensory evaluation of lactic acid fermented juices.

Evaluation of results: The data matrix were analyzed by the PCA method using SGWIN (STATGRAPHIC Plus) program for Windows, Version 1.4.

RESULTS AND DISCUSSION

For evaluation of the appearance of lactic acid fermented cabbage juices, the indexes juice colour, turbidity, sediment, and appearance were important. All evaluated samples had the same sediment. Noticeable differences were observed in the turbidity and the colours of juices. The differences were studied after sedimentation of juices. For the samples of lactic acid fermented cabbage juices, descriptors of colour and turbidity are shown in Table 1. From the results it is clear that fermented cabbage juices gained the most suitable colour and sediment at the fermentation duration of 72—96 h (samples A and B), which corresponded to light-orange, light orange-brown colour. The sample turbidity was moderate. At the next experiment (C samples), suitable fermentation time was between 24 h and 48 h; and like in the previous experiments, the observed colour was orange-brown and light orange-brown. After this fermentation time, the colour and turbidity of the samples worsened markedly. The assessors' task was to judge the suitability of sample colour and turbidity and consequently, find out the appearance of the samples. In the settled time intervals of fermentation, analyzed samples had adequate up to good total appearance (labelled by intensity from 3 to 5). After these fermentation hours, the total appearance worsened remarkably.

In the samples of lactic acid fermented juices, a group of assessors evaluated the intensity of selected flavour descriptors: sweet, acid, sweet-acid, cabbage, sharp, and smelling, which they labelled in the linear graph of sensory profile. The intensity values of selected flavour descriptors and appearance descriptor shown in Table 2 are average values and markedly outlying values of mostly assessors were excluded.

Resulting from the obtained data, at the beginning of fermentation, flavour descriptors sweet and cabbage prevailed in all experimental samples. The sweet flavour decreased during fermentation process to the value of 3.00 and cabbage flavour decreased to the value of 4.39. On the contrary, the acid flavour increased during fermentation process to the value of 5.75 (C samples) and was intermediately perceivable.

Table 1. Colour and Turbidity Description of Lactic Acid Fermented Cabbage Juices

Sample	Colour	Turbidity
A0	light yellow with green shade	soft
A24	light yellow-orange	weak
A48	light yellow with green-brown shade	soft
A72	light yellow-orange	soft
A96	light yellow-orange	soft
A120	light orange-brown	strong
B0	light yellow with green shade	soft
B24	light yellow with green-brown shade	soft
B48	light yellow with green-brown shade	soft
B72	light orange-brown	soft
B96	light orange-brown	strong
B120	light orange-brown	soft
C0	light yellow with green shade	soft
C24	light orange-brown	soft
C48	orange-brown	soft
C72	orange-brown	soft
C96	orange-brown	strong
C120	orange-brown	strong

The sweet-acid flavour intensified due to the overlapping of acid flavour through sweet flavour to the value of 4.48 and was intermediately perceivable. During the fermentation, flavour descriptors sharp and smelling also intensified. Their values were not high; intensities were very weakly perceivable and did not disruptively cause any changes during the whole fermentation; the highest values were reached in the fermentation time 96—120 h, when the assessors specified intensity from 1.90 to 2.13.

According to the assessors' results, the lactic acid fermented juices gained the most harmonic taste between 48 and 72 h of fermentation (samples of A and B set) and for C samples between 48—96 h. These time intervals are, from the viewpoint of flavour intensity of lactic acid fermented juices, the optimal.

For the taste evaluation of lactic acid fermented juices these taste descriptors were chosen: salt, sour, bitter, sweet, acid, sweet-acid, cabbage, and harmonic. The assessors' task was to record the intensity of every taste to the linear graph of sensory profile. At every taste, given distance was measured and afterward, from the numerical data, averaged value was calculated. The averaged values of taste intensities are shown in Table 3. From the results it seems that during fermentation the salt taste did not markedly change and for all the time it had the values from 2.49 to 3.96 with very weakly perceivable to perceivable intensity.

Descriptors of sour and bitter taste likewise did not acquire significant differences of the values. In the first fermentation hours in the samples prevailed very intensive sweet taste. The assessors most frequently specified its intensity up to the value of 6.88, that is intensity mediately strongly perceivable to strongly perceivable.

Table 2. Evaluation of Appearance and Flavour of Lactic Acid Fermented Vegetable Juices

Sample	General appearance	Flavour descriptors					
		Sweet	Acid	Sweet-Acid	Cabbage	Sharp	Smelling
A0	4.67	4.86	1.64	2.93	8.12	1.01	0.84
A24	4.04	4.85	3.66	3.96	6.28	1.50	1.96
A48	4.15	4.30	3.77	4.30	5.89	1.42	0.78
A72	4.34	3.86	3.86	4.07	5.39	1.01	0.47
A96	4.95	3.38	4.69	4.05	5.67	1.90	0.98
A120	4.01	3.67	4.80	4.48	5.61	1.90	0.57
B0	4.67	4.86	1.64	2.96	8.12	1.01	0.84
B24	4.19	4.05	1.91	2.45	5.56	0.44	1.04
B48	4.58	3.56	4.24	3.43	5.52	1.50	0.72
B72	4.70	3.49	4.76	3.67	5.47	1.15	0.54
B96	4.99	3.34	4.96	3.98	4.95	1.34	1.09
B120	4.57	3.00	5.04	4.12	4.96	1.60	1.19
C0	4.67	4.86	1.64	2.96	8.12	1.01	0.84
C24	3.56	4.68	2.44	3.07	5.70	0.85	1.93
C48	3.62	4.65	4.10	3.66	4.72	1.37	1.15
C72	4.00	3.66	5.35	4.30	5.23	1.50	1.34
C96	4.12	3.15	5.52	4.64	4.97	2.13	1.58
C120	3.22	3.06	5.75	4.47	4.39	1.92	1.85

Table 3. Taste Evaluation of Lactic Acid Fermented Cabbage Juices

Sample	Taste descriptors							
	Sweet	Salt	Acid	Sweet-Acid	Cabbage	Sour	Bitter	Harmonic
A0	6.88	2.49	1.38	1.95	8.01	1.14	0.97	2.18
A24	6.62	2.50	1.43	3.27	6.97	1.80	1.57	2.10
A48	2.65	2.80	6.23	3.77	6.14	1.90	1.96	3.02
A72	2.57	3.45	7.19	3.92	6.10	2.17	1.54	3.21
A96	2.47	3.05	7.28	4.02	6.05	2.14	1.54	3.80
A120	2.37	3.15	7.72	4.11	6.11	2.27	1.29	3.36
B0	6.88	2.49	1.38	1.95	8.01	1.14	0.97	2.18
B24	6.38	2.00	1.54	2.20	6.87	1.21	1.50	1.31
B48	4.00	3.48	5.65	4.09	6.40	1.28	1.10	2.52
B72	3.16	3.96	6.87	4.42	6.06	1.45	1.84	2.80
B96	2.48	3.61	6.59	4.51	6.35	1.50	1.04	4.07
B120	2.29	2.89	7.07	4.72	5.82	2.26	1.15	2.63
C0	6.88	2.49	1.38	1.95	8.01	1.14	0.97	2.01
C24	6.13	2.02	2.86	2.49	4.78	1.63	1.63	1.90
C48	4.08	3.08	5.62	2.83	6.60	1.42	1.50	3.64
C72	2.68	3.09	6.02	3.84	5.51	2.36	2.50	2.23
C96	2.17	3.35	6.56	3.99	5.66	2.14	2.30	2.59
C120	1.17	2.45	7.03	5.01	3.55	1.15	1.14	3.05

In all of the samples, at the beginning of evaluation, the assessors recognized tastes: acid and sweet-acid, the intensity of which increased as the fermentation continued; mostly, the acid taste became very intensive. At the end of fermentation, its intensity ranged from 7.03 to 7.72; the acid taste intensity was from intermediately to strongly perceivable.

During the last fermentation hours, the sweet taste acquired low intensity, weak susceptible that we can explain by the fact that during fermentation by lactic acid bacteria culture, the glucose content decreased gradually and organic acids in the higher concentration were formed; that explains also rising acid taste intensity.

The intensity of cabbage taste at the beginning of fermentation was strongly perceivable, during fermentation decreased to perceivable intensity. The sweet-cabbage taste during fermentation and its intensity was evaluated as intermediately perceivable. From the total evaluation we can see that the most harmonic taste of lactic acid fermented juices was reached between 72 h and 96 h of fermentation.

In Table 4 are shown results of analytical determination of samples of lactic acid fermented juices. During fermentation, pH value, total acidity, nitrites

Table 4. Results of the Analytical Determination of Lactic Acid Fermented Cabbage Juices

Sample	$m_r(NaNO_2)$ mg kg^{-1}	$m_r(NaNO_3)$ mg kg^{-1}	$m_r(NH_3)$ mg kg^{-1}	m_r(Total acidity) g kg^{-1}	pH	m_r(Organic acids) g kg^{-1}
A0	2.86	270.19	26.50	0.94	6.05	3.31
A24	2.95	174.68	29.90	1.10	5.87	3.63
A48	3.42	153.62	32.8	8.39	3.87	8.70
A72	3.33	126.11	33.10	10.27	3.75	8.91
A96	3.33	75.92	29.70	10.75	3.72	9.18
A120	2.19	28.97	29.00	10.78	3.71	9.42
B0	2.86	270.20	33.30	0.94	6.05	3.31
B24	3.21	150.39	42.20	1.23	5.87	3.37
B48	3.46	145.54	40.60	8.86	3.90	6.89
B72	3.43	103.44	34.50	10.34	3.76	7.71
B96	3.30	79.16	25.60	10.53	3.73	8.31
B120	1.46	40.31	27.40	10.87	3.72	8.44
C0	2.86	270.20	39.20	0.94	6.05	3.31
C24	3.04	150.07	59.80	2.732	4.88	4.56
C48	3.99	98.59	82.90	9.23	3.65	8.53
C72	4.25	62.97	87.00	13.26	3.45	12.29
C96	2.96	53.26	67.30	11.18	3.39	14.47
C120	1.07	27.36	47.10	13.42	3.31	14.47

Table 5. Correlation Coefficients for Analytical Variables

$NaNO_2$	$NaNO_3$	NH_3	Total acidity	pH	Organic acids
1.0000	0.2093	0.4146	−0.0614	0.0009	−0.1489
	1.0000	−0.2539	−0.8750	0.8734	−0.8221
		1.0000	0.2516	−0.2972	0.4042
			1.0000	−0.9757	0.9101
				1.0000	−0.8845
					1.0000

and nitrates content, ammonia and organic acids content were determined. In the course of lactic acid fermentation of cabbage juices inoculated by *Lactobacillus plantarum* 92H, pH value decreased and the total acidity increased and was expressed as content of lactic acid. In all of the experiments, an increase in the nitrites content was noticed. In the fermented juices inoculated with 2.2×10^8 CFU cm^{-3}, the nitrates content decreased from the initial value 270.20 to 27.36 mg kg^{-1} after 120 h of fermentation, which represents 89.87 %.

The increase in the nitrites content corresponded with the decrease in the nitrates concentration. In these experiments, the highest increase of nitrates was up to 48 h and 72 h of fermentation and decreased in the next period.

During fermentation, the ammonia content in the samples did not notably changed, except for the C samples.

The organic acids content increased in all samples from 3.31 to 14.47 g kg^{-1}.

Results obtained at the sensory evaluation and results of analytical determinations: The correlation analysis for measured analytical and sensory data was performed. The purpose of correlation analysis was to indicate and characterize of correlation between the variables that were measured in the juice samples. The correlation coefficients are presented in Tables 5 and 6.

From Table 5 it resulted that the highest values of correlation coefficients were found between total acidity and pH (−0.98), total acidity and content of organic acids (0.91), and between pH and content of organic acids (−0.88). The correlation coefficient between pH and total acidity indicates a high indirect linear dependence among these variables (during fermentation, pH decreased and total acidity increased as a consequence of activity of lactic acid bacteria, which produced mainly lactic acid). Correlation coefficient between total acidity and content of organic acids shows that between these variables exists direct linear dependence (increase of total acidity during fermentation correlates with increase of organic acids content). The small or zero values of correlation coefficients between variables indicated that the relationship between these variables was not linear.

At the assessment of taste descriptors of juices, the highest correlation between sweet and acid taste and between sweet and sweet-acid taste (−0.97 and −0.91, these data indicate high indirect linear dependence) was found.

Table 6. Correlation Coefficients for Sensory (Taste) Descriptors

Sweet	Salt	Acid	Sweet-Acid	Cabbage	Sour	Bitter	Harmonic
1.0000	−0.6174	−0.9700	−0.9131	0.6999	−0.5720	−0.3378	−0.6983
	1.0000	0.7120	0.6333	−0.0992	0.3446	0.2280	0.6361
		1.0000	0.8870	−0.6332	0.5943	0.3040	0.7545
			1.0000	−0.6917	0.4940	0.2199	0.6052
				1.0000	−0.3433	−0.3763	−0.2651
					1.0000	0.5877	0.3039
						1.0000	−0.0602
							1.0000

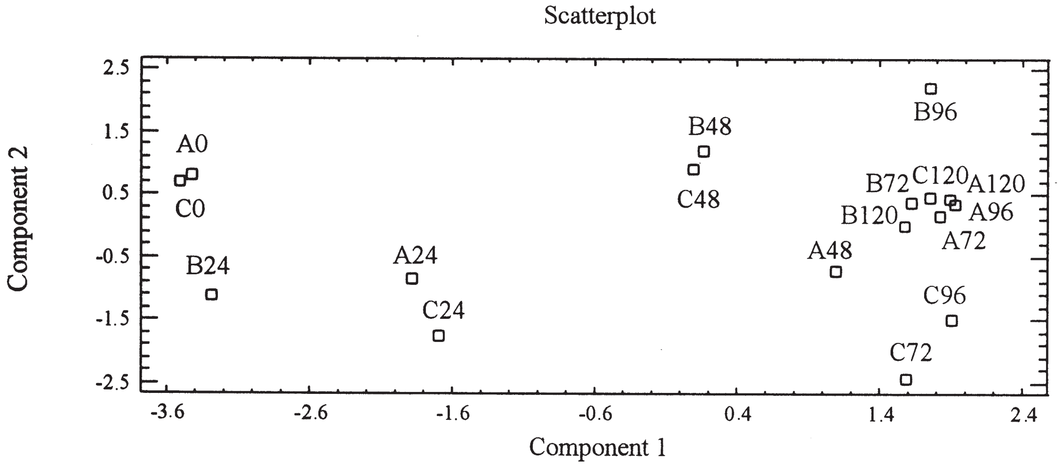

Fig. 1. Scores plot of principal component PC1 *vs.* PC2 for 18 juice samples and 8 taste descriptors.

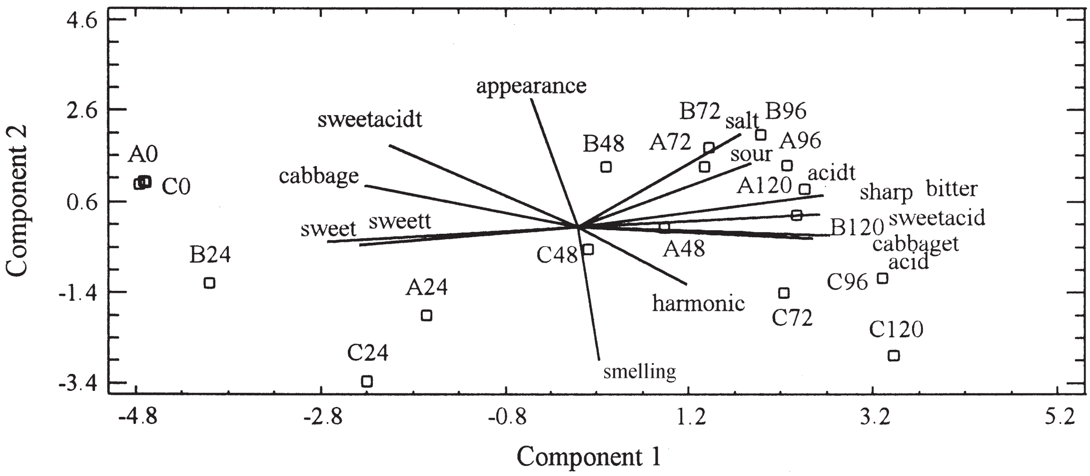

Fig. 2. Scores plot and loading plot of PC1 *vs.* PC2 for 18 juice samples and 15 sensory descriptors (taste, flavour, and appearance).

During fermentation, the eighteen samples of lactic acid fermented cabbage juices were obtained. For every sample in the course of 120 h, the 23 variables, sensory (flavour: acid, sweet, sweet-acid, cabbage sharp, smelling; taste: salt, sweet, sweet-acid, acid, cabbage, sour, bitter, harmonic; and appearance) and analytical (nitrites, nitrates, ammonia, total acidity, pH, and organic acids (lactic, acetic, and citric acid)) were followed. In this work the results of sensory evaluation (data matrix 18 × 8 for 18 samples and 8 taste descriptors and data matrix 18 × 15 for 18 samples and 8 taste descriptors, 6 flavour descriptors, and appearance descriptor) are shown in Figs. 1 and 2. In Fig. 3 are shown results of analytical determinations (data matrix 18 × 6 for 18 samples and 6 analytical descriptors).

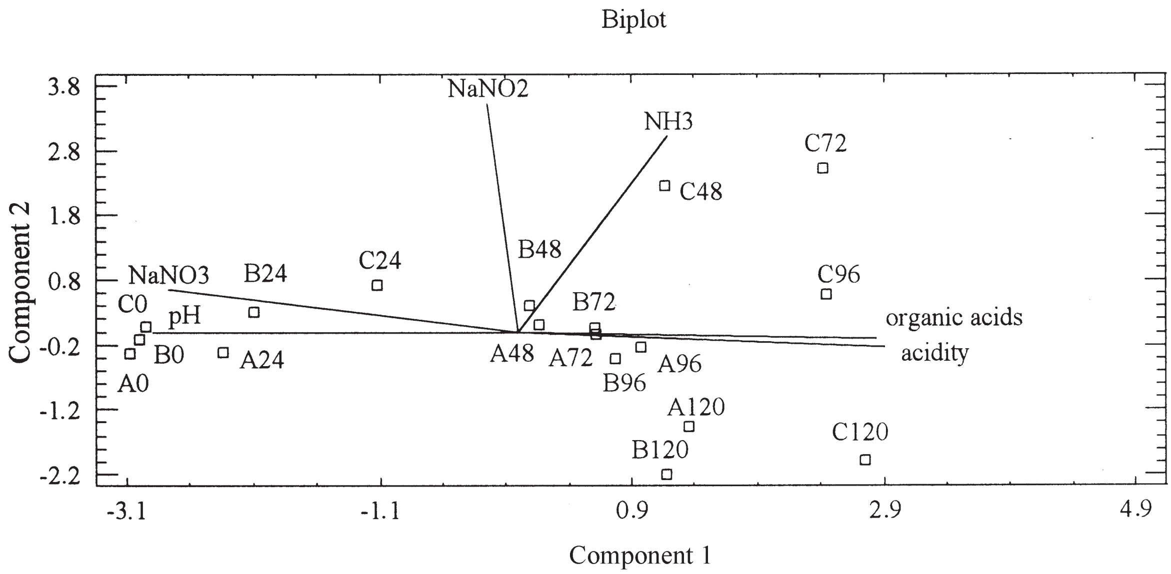

Fig. 3. Scores plot and loading plot of PC1 *vs.* PC2 for 18 juice samples and 6 analytical descriptors.

In Fig. 1 are plotted objects (juices) in coordinates PC1 (first principal component) and PC2 (second principal component) (data matrix 18 × 8). The PC1 explained 60.50 % from the total variance of data and PC2 next 16.80 % from the total variance of data. The C0 sample covered with the B0 sample, for this reason this sample was not labelled in Fig. 1. In this figure it is possible to see the fermentation. The samples are situated according to fermentation time in orientation from negative to positive part of the first principal component. The PC1 mostly described samples of A0, B0 and samples of A120, B120, C120. The PC2 explains mostly samples C24, B48, B72. In Fig. 1 we can see clusters of samples at the same time of fermentation, which are distinguished only with the content of inoculum in the samples.

In Fig. 2 are in the coordinates PC1 and PC2 plotted scores of objects (juices samples) and loading of variables (taste descriptors, flavour descriptors labelled with suffix t and appearance descriptor).

PCA reduced the 15 variables to three independent components, which accounted for 79.80 % of the total variance (PC1 54.10 %, PC2 17.40 %, and PC3 next 8.30 %).

The PCA allowed to select taste (acid, sweet-acid, sharp, bitter, cabbage, sweet) and flavour (cabbaget, acidt, sweet-acidt, sweett) descriptors which were the most important for evaluation of cabbage juices.

The principal component loading allows to explain correlation between variables. It can be seen that variable cabbage negatively correlated with variable cabbaget and variables sweett and sweet positively correlated together.

In Fig. 3 in the coordinates PC1 and PC2 are plotted scores of samples and loading of analytical variables. PCA reduced the 6 analytical variables to two independent components, which accounted for 87.10 % of the total variance (PC1 63.80 % and PC2 next 23.30 %).

The PC1 separated juices with the highest content of organic acids and the highest total acidity (the end of fermentation) and juices with the highest content of nitrates and the highest pH value (the initial hours of fermentation). The PC2 separated juices with the highest content of nitrites and ammonia.

The PCA selected analytical (organic acids, acidity, pH, $NaNO_3$) and sensory variables which were the most important for evaluation of cabbage juices.

The PCA method allows in this case visual representation of data in new coordinates – the coordinates of principal component, in which scores of samples, and also loading of variables were plotted. From these graphical plottings established for every case we can see how the samples correlate in individual fermentation hours, as well as the correlation between variables, *i.e.* the original variables mutually positively or negatively correlate, and mutual correlation of samples and variables.

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