Optimisation of Method of Fermentation of Cabbage Juice

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Abstract

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Cabbage juices were inoculated with various microorganisms (*Lactobacillus plantarum* 92H, *Lactobacillus plantarum* CCM 7039, a mixed starter culture consisting of *Lactobacillus plantarum* 92H and *Saccharomyces cerevisiae* C11-3) and fermented spontaneously in a thermostat at 22°C for 168 hours. During fermentation, the analytical and sensory parameters were followed. We found that the most suitable bacteria for the fermentation of cabbage juices was *Lactobacillus plantarum* CCM 7039 (highest production of lactic acid, sufficient decreasing of pH value, highest intensity of harmonic taste and acceptance of odour and taste). Cabbage juices fermented either with the mixed starter culture or spontaneously contained, at the end of fermentation, cadaverine (48.02–78.68 mg/dm^3) and putrescine (82.40–202.95 mg/dm^3). The contents of histamine and tyramine were under the limit of quantification in all juices. Optimal sensory characteristics were reached during 72nd hour of fermentation of cabbage juice inoculated with *Lactobacillus plantarum* CCM 7039, and during 96th hour of fermentation for the other juices.

Keywords: fermentation; cabbage juice; optimisation; organic acids; biogenic amines; sensory analysis

Preservation of foods by fermentation is a widely practiced and ancient technology (Caplice & Fitzerald 1999). The fundamental reason for the development and acceptance of fermented foods can be variably ascribed to preservation, improved nutritional properties, better flavour/aroma, upgrading of substrates to higher value products, and improved health aspects (Kalantzopoulos 1997).

The safety of food fermentation is related to several principles. The first principle is that the food substrates overgrown with desirable, edible microorganisms become resistant to the invasion by spoilage – causing or toxic or food poisoning microorganisms. The second principle resides in that the fermentations involving the production of lactic acid are generally safe. Lactic acid fermentations include those in which the fermentable sugars are converted to lactic acid by organisms such as *Leuconostoc mesenteroides*, *Lactobacillus brevis*, *Lactobacillus plantarum*, *Pediococcus cerevisiae*, *Bifidobacterium bifidus* etc. (Steinkraus 1997).

The lactic acid bacteria have also several potential health or nutritional benefits (Gilliland 1990). Among these are: an improved nutritional value of food (Kalantzopoulos 1997), the control of intestinal infections (Nout & Ngoddy 1997), the control of some cancer types (Klaenhammer 1995),

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and the control of serum cholesterol levels (Kaur *et al*. 2002).

The nutritional impact of fermented foods on nutritional diseases can be direct or indirect. Food fermentations that enhance the protein content or improve the balance of essential amino acids or their availability will have a direct curative effect. Similarly, fermentations that increase the contents or availability of vitamins such as thiamine, riboflavin, niacin, or folic acid can have profound direct effects on the health of the consumers of such foods (Steinkraus 1997). Fermentation may reduce the contents of indigestible materials in plant foods, such as cellulose, hemicellulose, and polygalacturonic and glucuronic acids. The breakdown of these compounds may lead to an improved bioavailability of mineral and trace elements (Kalantzopoulos 1997).

While there are 21 different kinds of commercial vegetable fermentation in Europe along with a large number of fermented vegetable juices and blends, the most economically relevant of these are the fermentations of olives, of cucumbers (pickles), and of cabbage (sauerkraut, Korean kimchi) (Caplice & Fitzerald 1999).

In a number of countries, the consumption of the lactic acid fermented vegetable juices increases (Kopec 2000). The vegetable juices processed by lactic acid fermentation introduced a change in the beverage assortment due to their high nutritive value (Karovičová & Kohajdová 2002a) and high contents of vitamins and mineral compounds (Lee 1997).

The lactic acid fermented vegetable juices can be produced by two procedures: the vegetable is first fermented in a usual way and then it is processed by pressing out the juice (manufacture of sauerkraut), or the vegetable is at first processed to mash or raw juice and it is consecutively fermented (Hammes 1990). By the fermentation, the juices obtain, a pleasant acid taste and, a characteristic aroma (Biacs 1986).

The purpose of this work was:

1. to compare the fermentation course of cabbage juices inoculated by *Lactobacillus plantarum* 92H, *Lactobacillus plantarum* CCM 7039, the mixed starter culture of *Lactobacillus plantarum* 92H and yeast *Saccharomyces cerevisiae* C11-3, and spontaneously fermented cabbage juice; and to select the starter culture that was the most suitable for the fermentation of cabbage juices from the analytical and sensory points of view;
2. to determine the time in which the fermentation of juices should be terminated;
3. to apply the analysis of the basic components and to select the most important variables for these juices.

MATERIALS AND METHODS

Preparation of vegetable juices. Fresh cabbage was purchased in a local market in Slovakia. The outer leaves were removed and the cabbage was chopped into small slices. The juice was obtained by pressing and filtration of the crushed cabbage. After the filtration, the juice was fortified by the addition of 2% D-glucose and 0.5% NaCl.

The juices were consequently inoculated by *Lactobacillus plantarum* 92H (92H) at the concentration of 10^6 CFU/ml, *Lactobacillus plantarum* CCM 7039 (CCM) at the concentration of 10^6 CFU/ml, the mixed starter culture of *Lactobacillus plantarum* 92H and yeast *Saccharomyces cerevisiae* C11-3 at the concentration of 10^6 CFU/ml and 10^3 CFU/ml (MIX), and were also spontaneously fermented (S). After the inoculation, the samples were placed into 250 cm^3 sterile flasks. Every flask represented a single sample. The flasks were closed with sterile rubber stoppers (carbon dioxide formed during fermentation process ensured anaerobic conditions over the surface of juice). The juices were fermented in a thermostat at 22°C for 168 h. During fermentation, samples of the juices were taken for the analytical determinations and sensory evaluation. The experiments were performed triplicate and also with other raw materials. These results were published by Karovičová and Kohajdová (2002a, b) and Karovičová *et al*. (2002).

Microorganisms. *Lactobacillus plantarum* 92H was isolated from sauerkraut and was verified by biochemical tests. *Lactobacillus plantarum* CCM 7039 originated from the Czech collection of microorganisms, Brno. *Saccharomyses cerevisiae* C11-3 originated from the collection of Biochemical Technology STU, Bratislava. The *Lactobacillus* strains were multiplied in LS broth (LS – *Lactobacillus* selective broth). The broth was sterilised 20 min at 121°C. The cultures were incubated at 37°C during 16–18 h. After incubation, the cultures were cultivated to plates at 37°C during 48 h. The yeast was cultivated on GKCH broth (GKCH – medium with yeast extract, glucose and chloramphenicol) at 25°C for 3 days. The initial concentration of microorganism was determined by means of the plate count on pour

plates (LS-agar, Imuna Šarišské Michaľany). The pour plates were incubated for 24–48 h at 37°C and the bacteria were counted (CFU/ml).

Analytical methods. The samples of juices were refrigerated and prior to the analytical determinations, the frozen samples were defrosted and analysed at a stroke.

The measurement of pH was performed using a LABOR-pH-meter CG-834 (Schott, Germany). The total acidity was determined by the visual titration with 0.1M solution of NaOH using phenolphtalein indicator and expressed as lactic acid. The determination of reducing sugars was performed according to Schoorl. The non-reacted Cu^{2+} was determined after the formation of Cu_2O. The KI was oxidised by $CuSO_4$ to I_2 that was determined by titration with $Na_2S_2O_3$.

Isotachophoretic measurements were done on the isotachophoretic analyser ZKI 01 (Villa Labeco Spišská N. Ves) with conductivity detector. For the identification and determination of biogenic amines (histamine, cadaverine, tyramine, putrescine), the electrolyte systems of the following compositions were applied:

leading electrolyte (LE): 10^{-2} mol/dm^3 KOH, valine, pH 9.9,

terminating electrolyte (TE): 2×10^{-2} mol/dm^3 TRIS, HCl, pH 8.3. The samples were analysed at the driving current of 150 μA (Karovičová *et al*. 2003).

For the identification and determination of organic acids (citric, acetic, lactic L-ascorbic acids):

LE: 10 mmol/dm^3 HCl, 0.1% MHEC, aminocaproic acid, pH 4.25,

TE: 5 mmol/dm^3 caproic acid (Karovičová & Kohajdová 2002a, b). The current in the preseparation column was 250 μA. The samples were injected using 30 μl fixed volume. Quantitative analysis was performed by calibration. The limits of determination for the acids ranged from 1.62 mg/dm^3 (citric acid) to 2.10 mg/dm^3 (L-ascorbic acid), and those for biogenic amines from 1.02 mg/dm^3 (putrescine) to 2.32 mg/dm^3 (cadaverine).

The relative standard deviations at the determination of acids ranged from 1.15% to 4.78%, and those of amines from 1.01% to 4.22%. The recovery ranged from 91.5% to 96.5% for acids, and from 95.4% to 104.9% for amines.

Sensory evaluation. The samples were evaluated by a panel of 10 assessors. Prior to the sensory evaluation, the frozen samples were defrosted and warmed to laboratory temperature. The temperature of the samples evaluated was 15–18°C.

During fermentation, the sensory parameters such as turbidity, colour, sediment, appearance, odour, and taste were evaluated. Turbidity and appearance (appearance represents overall appearance of juice) were evaluated by a 5-point intensity scale (1 – nonturbid, 5 – very strongly turbid, and 1 – nontypical, 5 – typical for given juice). The colour was evaluated by 6-point scale (1 – light yellow with green shade, 2 – light yellow with green brown shade, 3 – light yellow orange, 4 – light orange brown, 5 – orange brown, 6 – creamy orange). For the evaluation of odour and taste, 100 mm graphical non-structured abscissas with the description of extreme points were applied (minimal or maximal intensity of descriptors). For odour evaluation, the following odour descriptors were applied: sweet, acid, cabbage, sharp, smelly, sweet-acid and spicy. For the taste evaluation, the following taste descriptors were applied: sweet, acid, cabbage, sweet-acid, harmonic, salty, sharp, spicy, and bitter.

Statistical methods. For the evaluation of the analytical and sensory results, the multivariate statistic methods were applied – principal component analysis (PCA) and cluster analysis. The results were arranged into data matrix and analysed using the statistic program SGWIN (Statgraphic for Windows) Version 1.4.

RESULTS AND DISCUSSION

Before the start of fermentation, the juices had the following analytical parameters: pH of the juices ranged from 5 to 6.3, total acidity varied between 1.5 g/dm^3 and 2.4 g/dm^3.

From the viewpoint of optimal lactic acid fermentation course, the content of sugars in raw materials must be sufficient i.e. at least 40 g/dm^3 (Kopec 2000). 2% of D-glucose was added to the juices. The content of reducing sugars after the addition of glucose varied from 49.80 g/dm^3 to 74.50 g/dm^3.

Kopec (2000) and Holzapfel (2002) found that during fermentation, the pH value of lactic acid fermented vegetable juices decreased from 6–6.5 to 3.8–4.5. Our results showed that the pH of cabbage juices decreased to values between 3.50 (CCM) and 4.05 (92H and S). The highest decrease of pH was achieved in cabbage juice inoculated with mixed starter culture (from value 6.3 to 3.8) (Figure 1). At

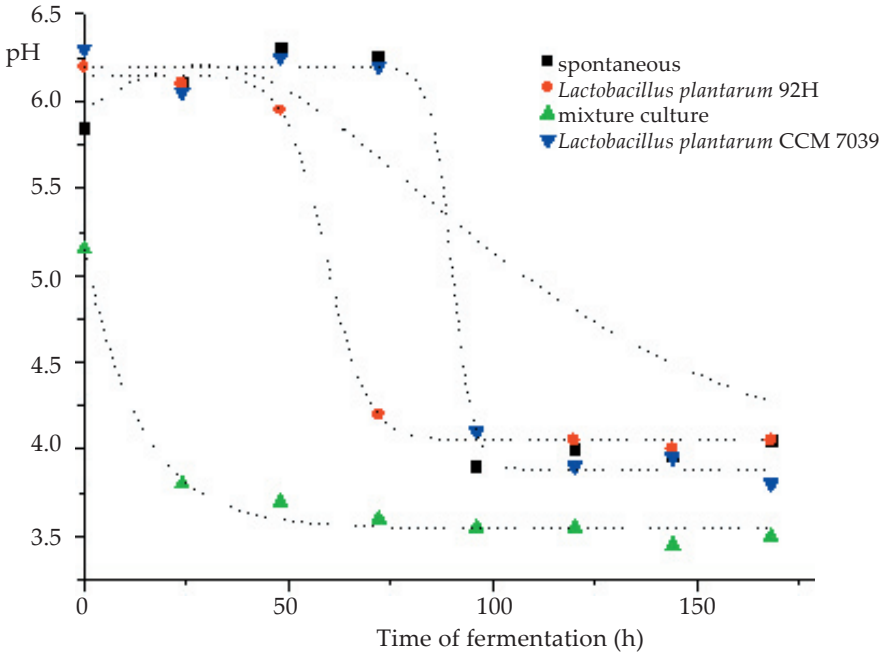

Figure 1. Changes of pH in course of cabbage juices fermentation

the end of fermentation, the total acidity of juices (expressed as lactic acid) varied from 8.80 g/dm^3 (S) to 14.80 g/dm^3 (CCM).

According to Kopec (2002) in the lactic acid fermented vegetable products, 20 to 70% from the initial content of vitamin C is retained in the dependence on the correct manufacturing practice. At the end of fermentation, the cabbage juices contained more than 40% of L-ascorbic acid originally present in raw materials. It was found that the highest concentration of L-ascorbic acid was maintained in the cabbage juice fermented by *Lactobacillus plantarum* CCM 7039 and the mixed starter culture: 56.2% and 57%, respectively, from the original content present in raw materials.

In the application of the mixed starter culture of *Lactobacillus plantarum* and *Saccharomyces cerevisiae*, a more complex utilisation of sugars is achieved (Montaño *et al*. 1997). Association of lactic acid bacteria and yeasts during fermentation may also contribute metabolites, which could impart taste and flavour to fermented food (Mugula *et al*. 2003).

The strains of bacteria used in this work were selected according to Karovičová *et al*. (1999) and culture of yeast was selected according to Montaño *et al*. (1997). During the fermentation of cabbage juices, the sugars were utilised by lactic acid bacteria. At the end of the fermentation process, all juices, with the exception of the juice inoculated with the mixed starter culture, contained 54% (CCM) to 59.9% (S) from the original concentration of the reducing sugars present in the raw materials. Cabbage juices fermented by the mixed starter culture contained only 41.4% from the original concentration of reducing sugars present in the raw material.

In the course of fermentation, the production of lactic and acetic acids, and the utilisation of citric acid was recorded. In Figures 2 and 3, the relation is plotted between the concentration of lactic or acetic acid and the time of fermentation. The highest concentration of lactic acid was recorded in cabbage juices fermented by *Lactobacillus plantarum* CCM 7039 (18 g/dm^3 in the 168th h of fermentation), and of acetic acid in cabbage juices fermented by *Lactobacillus plantarum* 92H and the mixed starter culture (4.65 g/dm^3 and 4.43 g/dm^3 in 168th h of fermentation). It was found that, in the cabbage juice fermented by *Lactobacillus plantarum* CCM 7039, the highest concentration of lactic acid and the lowest concentration of acetic acid was produced. At the end of fermentation, the juices contained from 3% (92H) to 33.2% (CCM) from the original concentration of citric acid present in the raw material.

Kirschbaum *et al*. (1997, 1999) found in bottled and pasteurised sauerkraut juices from Germany extremely high amounts of putrescine (up to 229 or 694 mg/dm^3), and in lactic acid fermented cabbage juices from Germany 38.3–62.9 mg/dm^3 of histamine, 37.1–73 mg/dm^3 of tyramine, 83.5–366 mg

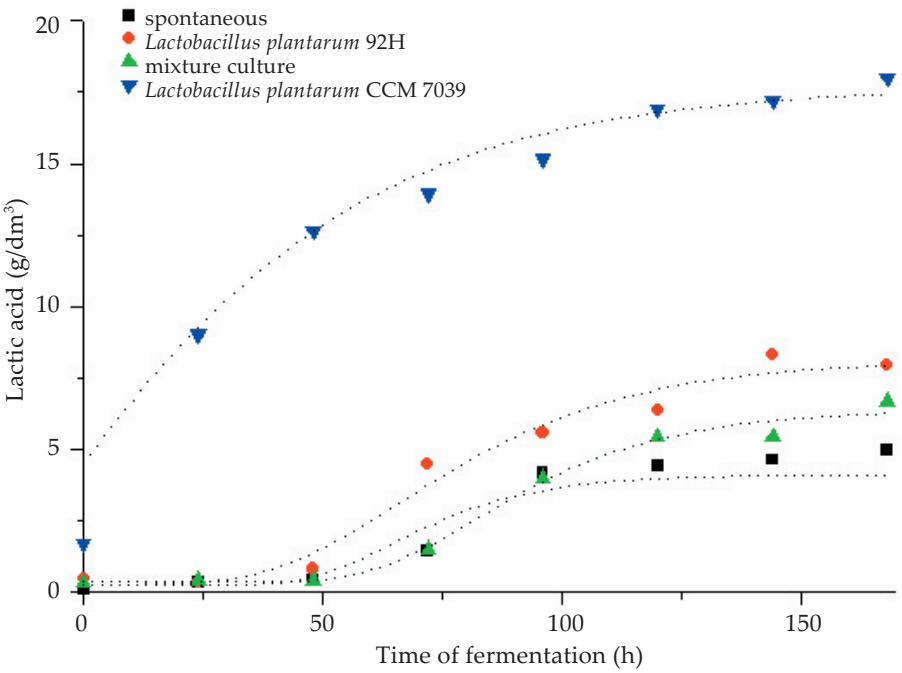

Figure 2. Changes of lactic acid in course of cabbage juices fermentation

per kg[3] of putrescine, and 18.9–59.4 mg/dm[3] of cadaverine (Kirschbaum *et al*. 2000). In the course of fermentation of cabbage juices, we found the contents of histamine and tyramine to be under the limits of quantification of the methods used for all juices. Cadaverine and putrescine were present only in the spontaneously fermented cabbage juice from the start of fermentation up to the end of the fermentation process (cadaverine from 48.02 to 68.46 mg/dm[3] and putrescine from 82.40 to 202.95 mg/dm[3]), and in cabbage juice fermented by the mixed culture (cadaverine from 48.02 to 78.68 mg/dm[3] and putrescine from 85.58 to 159.06 mg/dm[3]). Kolesárová (1995) and Kalač *et al*. (1997) recommended as prevention for histamine production the stop fermentation process when the pH of juices is between 3.8 and 4 and total acidity is between 9 g/kg and 10 g/kg. Our results corresponded with these recommendations. Application of *Lactobacillus plantarum* as starter culture is possible to prevent histamine formation (Kolesárová 1995). We found that in the

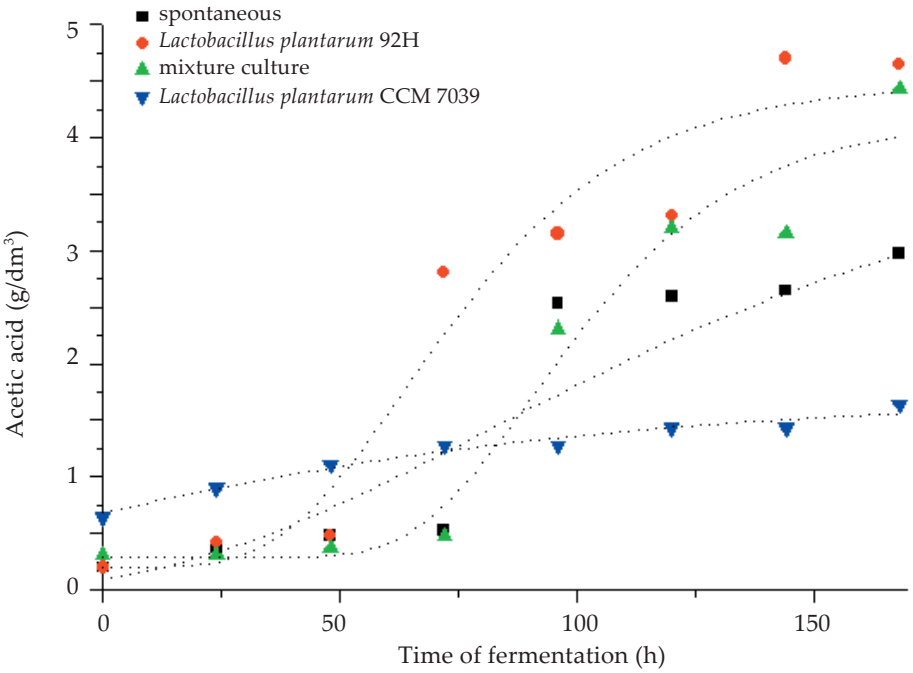

Figure 3. Changes of acetic acid in course of cabbage juices fermentation

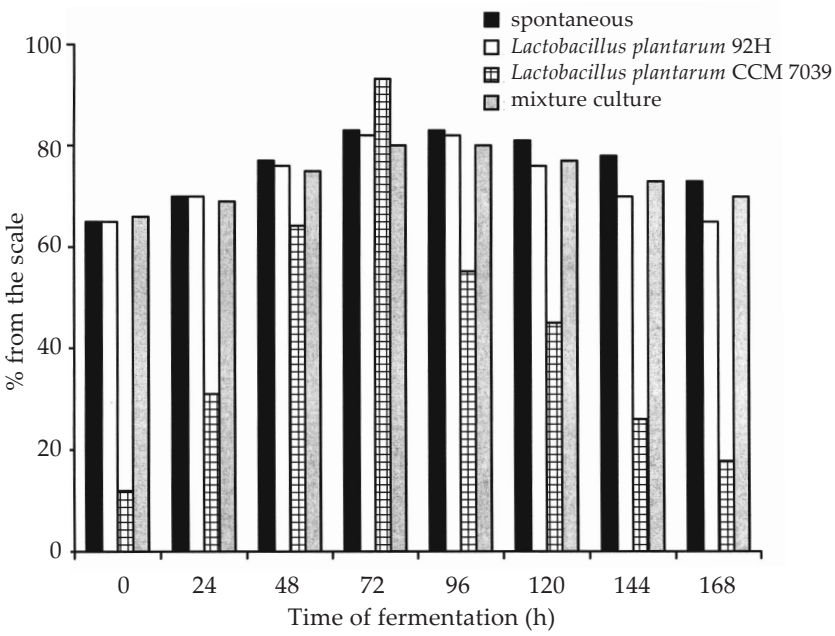

Figure 4. Changes of harmonic taste during fermentation of cabbage juices

cabbage juices fermented by strains of *Lactobacillus plantarum* was the content of this amine under the limit of quantification.

The purpose of the sensory analysis was to select the most acceptable juice for consumers. Harmonic taste was the main criterion for the selection of juices from the sensory point of view. Harmonic taste represents the taste characterised by other taste descriptors in the optimal proportions. In Figure 4, changes are presented of harmonic taste during the fermentation of vegetable juices. The highest harmonic taste intensity of juices was recorded in the cabbage juice fermented by *Lactobacillus plantarum* CCM 7039 (93.2% from the scale) in the 72nd h of fermentation. In other juices, the highest harmonic taste intensity was recorded in the 72nd and 96th h of fermentation. In these fermentation times, the spontaneously fermented cabbage juice reached 83% of the harmonic taste intensity, cabbage juice fermented by *Lactobacillus plantarum* 92H 82%, and cabbage juice fermented by the mixed culture 80% of the scale.

The spontaneously fermented cabbage juice had in 72nd and 96th h of fermentation medium turbidity and a light yellow colour with a green shade as well as the typical appearance.

It was found that in the 72nd h of fermentation, the spontaneously fermented cabbage juice had a pH value of 6.25 and the contents of lactic and acetic acids were only 1.42 g/dm^3 and 0.53 g/dm^3, and in the 96th h of fermentation the pH value was 3.9 and the content of lactic acid was 4.16 g/dm^3 and that of acetic acid 2.54 g/dm^3.

The cabbage juice fermented by *Lactobacillus plantarum* CCM 7039 had in the 72nd h of fermentation medium turbidity and a cream orange brown colour with a green shade and the typical appearance. It was found that, in the 72nd h of fermentation, this juice had pH value of 3.6 and the contents of lactic and acetic acids were 13.97 g/dm^3 and 1.27 g/dm^3, respectively.

The cabbage juice fermented by *Lactobacillus plantarum* 92H had in the 72nd and 96th h of fermentation medium turbidity and a light yellow colour with a green shade and the typical appearance. It was found that in the 72nd h of fermentation, this juice had the pH value of 4.2 and the contents of lactic and acetic acids were 4.48 g/dm^3 and 2.81 g/dm^3, respectively, and in the 96th h of fermentation the pH value was 4.10 and the contents of lactic and acetic acids were 5.57 g/dm^3 and 3.15 g/dm^3, respectively.

The cabbage juice fermented by the mixed starter culture had in the 72nd and 96th h of fermentation medium turbidity and a light yellow colour with a green shade and the typical appearance. It was found that, in the 72nd h of fermentation, this juice had the pH value of 6.2 and the contents of lactic and acetic acids were only 1.51 g/dm^3 and 0.48 g/dm^3, respectively. In the 96th h of fermentation, the pH value was 4.1 and the content of lactic acid was 4.01 g/dm^3 and that of acetic acid 2.31 g/dm^3, respectively.

In Figures 5 and 6, sensory profile graphical charts are presented of odour and taste in the 72nd h of fermentation. The cabbage juice fermented by *Lacto-*

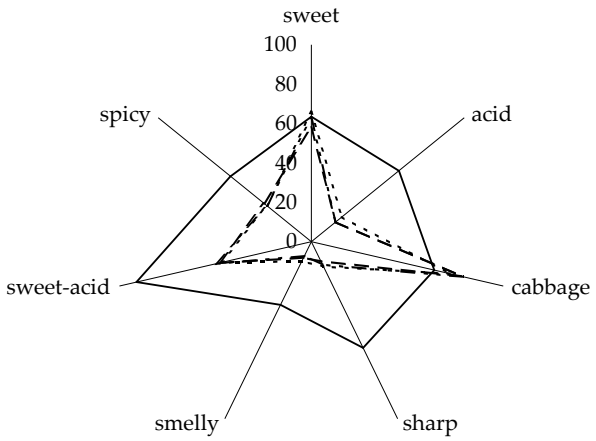

Figure 5. Graphical chart sensory profile of odour for cabbage juices (72nd h of fermentation) (— spontaneous, ··· *Lactobacillus plantarum* 92H, – – – *Lactobacillus plantarum* CCM 7039, — · — mixture culture)

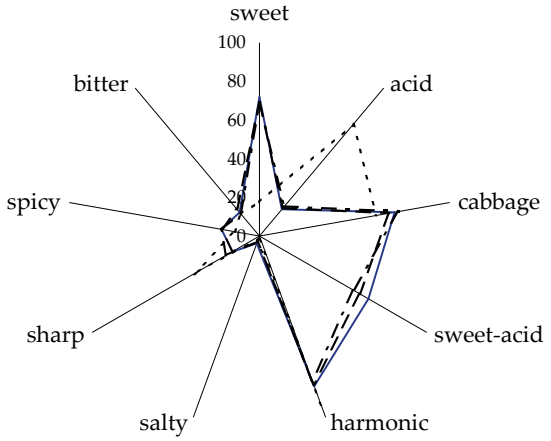

Figure 6. Graphical chart sensory profile of taste for cabbage juices (72nd h of fermentation) (— spontaneous, ··· *Lactobacillus plantarum* 92H, – – – *Lactobacillus plantarum* CCM 7039, — · — mixture culture)

bacillus plantarum CCM 7039 had, in comparison with other juices in the 72nd h of fermentation, the highest intensity of sweet-acid, sharp, acid, and spicy odour and the highest intensity of acid taste.

The evaluation of the acceptance of odour, of taste and of flavour was also done. In Figures 7–9, the changes are presented of these sensory parameters in the course of fermentation. The highest intensity of these sensory parameters was reached in the cabbage juice fermented by *Lactobacillus plantarum* CCM 7039 in the 72nd h of fermentation (83.5%, 89.3% and 91.5% of the scale). In other juices, the highest intensity of these sensory parameters was recorded in the 96th h of fermentation.

From the analytical and sensory points of view, we recommend to interrupt the fermentation of the cabbage juice inoculated by *Lactobacillus plantarum* CCM 7039 in the 72nd h of fermentation, and of other juices in the 96th h of fermentation.

Evaluation of results by multivariate statistical methods

In view that during fermentation a large amount of results was obtained, these were evaluated by

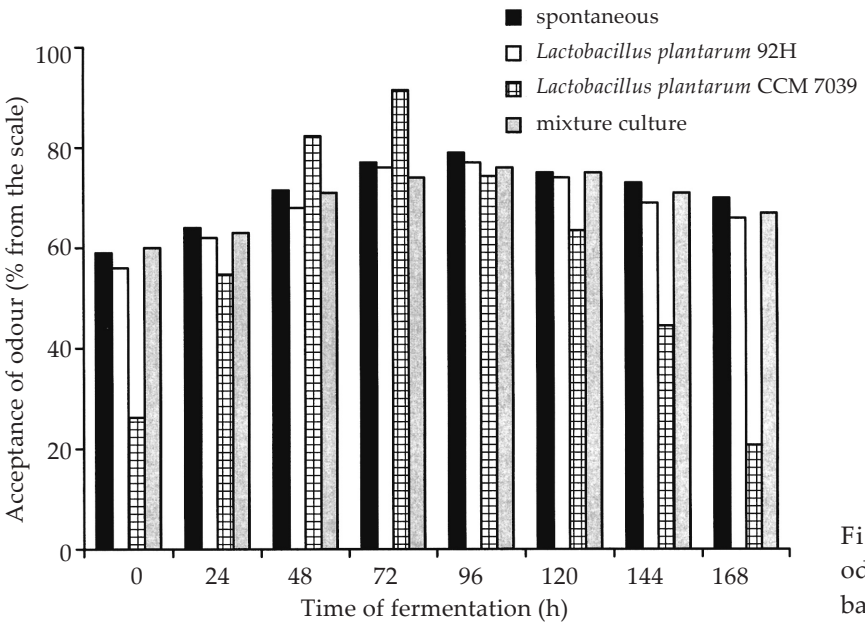

Figure 7. Changes acceptance of odour during fermentation of cabbage juices

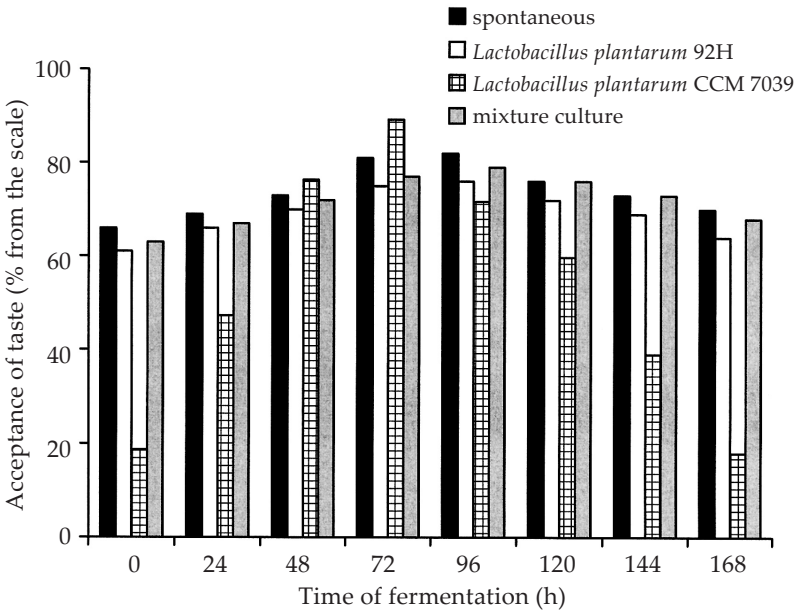

Figure 8. Changes in acceptance of taste during fermentation of cabbage juices

multivariate statistical methods: principal component analysis (PCA) and cluster analysis (CA). PCA was used to reduce the dimensionality of a set of variables by constructing uncorrelated linear combinations of them, and the purpose of CA was to classify juices into clusters on the basis of their similarity.

PCA reduced the original 7 analytical variables to 2 independent components that explained 88.2% from total variance of input data (PC1 – first principal component 66.9% and PC2 – second principal component 21.3%). The PC1 best describes the total acidity, pH, and the contents of reducing sugars and lactic and acetic acids, the PC2 best explains the content of ascorbic acid. Eliminating the variable of ascorbic acid, the one principal component that accounted only for 73.4% from total variance was extracted. It was found that for maintaining a sufficient amount of information contained in the original variable, it is essential to determine all of the analytical parameters used. In Figure 10 are plotted the score of samples in coordinates of the first two principal components. From Figure 10 it is evident that the PC1 best explained the samples in

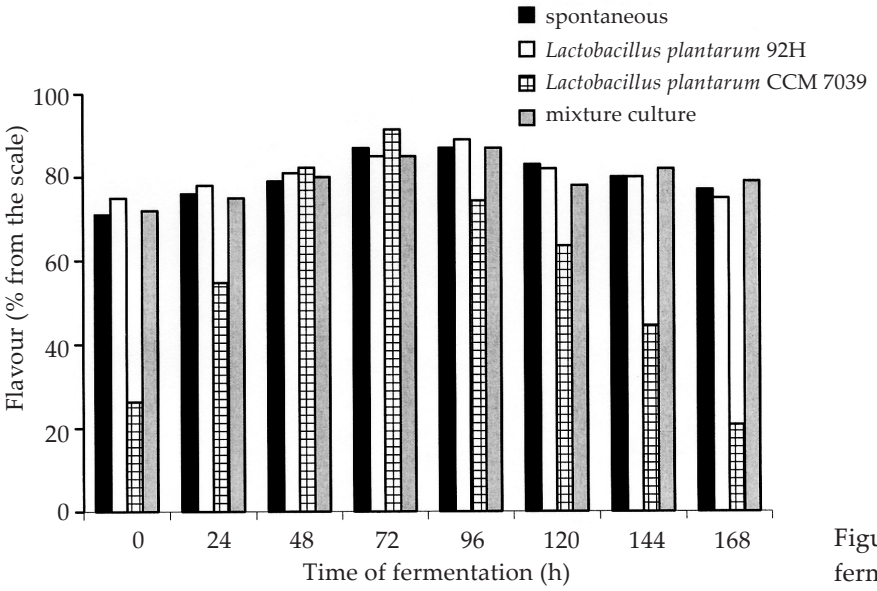

Figure 9. Changes of flavour during fermentation of cabbage juices

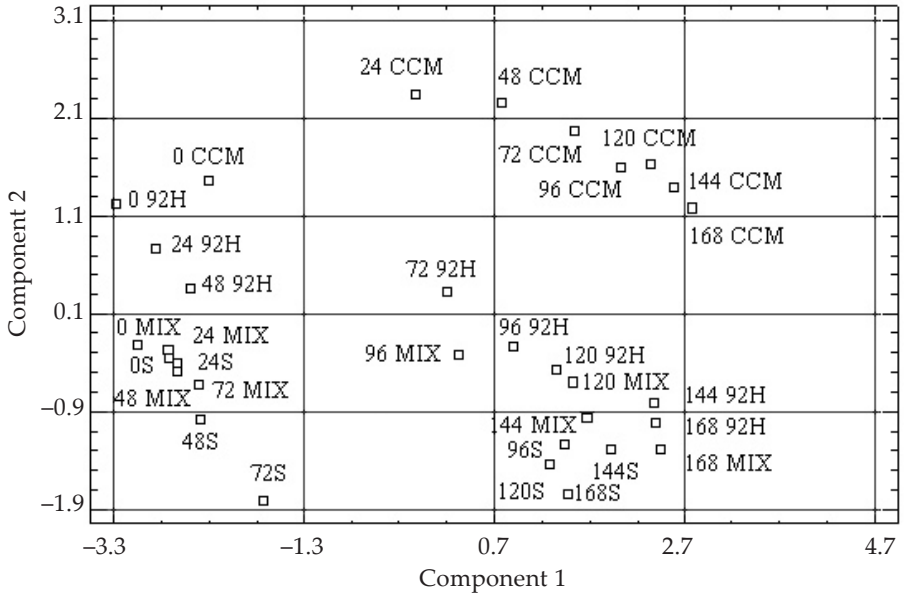

Figure 10. Plotting score of samples in coordinates of first two principal components

the start of fermentation (0–48th h of fermentation) and the samples at the end of fermentation.

PCA reduced the original 7 odour descriptors to one principal component that accounted for 80.1% from the total variance. All variables except the sweet-acid variable were explained nearly to identical level. Sweet-acid odour was explained by PC1 nearly to zero level. Omitting this variable, one principal component was extracted that accounted for 91.6% from the total variance. It was found that the use of six odour descriptors (without the sweet-acid descriptor) is sufficient for the odour evaluation of the lactic acid fermented cabbage juices.

PCA reduced the original 9 taste descriptors to three principal components that accounted for 95.5% from total variance (PC1 53.3%, PC2 28.7%, and PC3 13.5%). Figure 11 shows that the PC1 best describes the following variables: acid, cabbage, sharp, and sweet, and PC2 and PC3 harmonic taste. By the application of PCA to these five variables only, 2 principal components were extracted that accounted for 90.7% from total variance.

In Figure 12 are presented the results of cluster analysis (clustering method: Centroid, Distance metric: squared Euclidean) for the taste descriptor of juices. By cluster analysis, samples were divided into five groups:

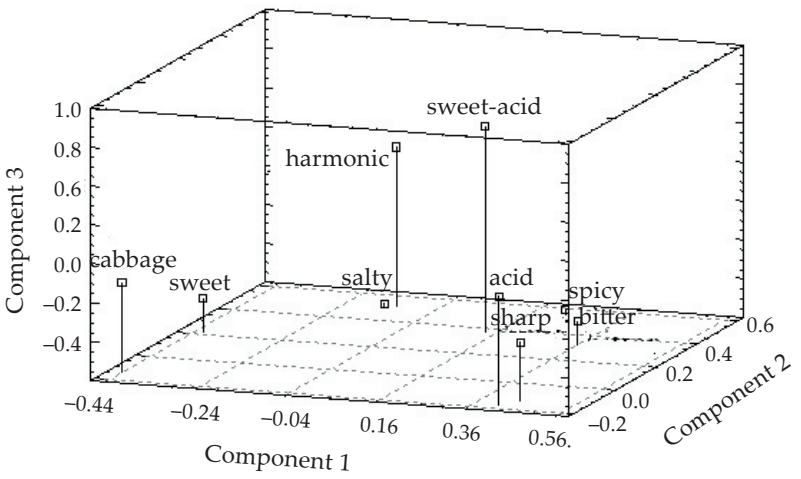

Figure 11. Plotting component weights taste descriptors of juices in coordinates of first three principal components

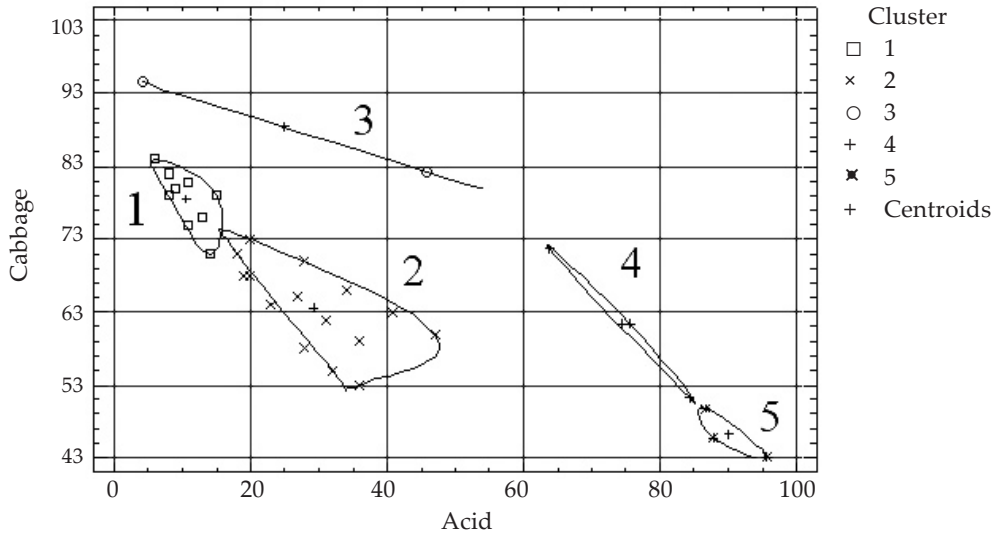

Figure 12. Results of cluster analysis for taste descriptors of cabbage juices (clusters of samples in axes of two selected variables-acid and cabbage)

Group 1: samples inoculated by *Lactobacillus plantarum* 92H, the mixed starter culture, or spontaneously fermented samples from 0th to 48th h of fermentation;

Group 2: samples inoculated with *Lactobacillus plantarum* 92H, the mixed starter culture, or spontaneously fermented samples from 72nd to 168th h of fermentation that had the lowest intensity of the acid taste (from 6 to 14% from the scale);

Group 3: samples inoculated by *Lactobacillus plantarum* CCM 7039 in 0th and 24th h of fermentation (the highest increase of acid taste during 24th h (from 4.2 to 45.8% from the scale);

Group 4: samples inoculated with *Lactobacillus plantarum* CCM 7039 from 48th to 96th h of fermentation;

Group 5: samples inoculated with *Lactobacillus plantarum* CCM 7039 from 120th to 168th h of fermentation which had the highest intensity of the acid taste (from 86.7 to 95.7% from the scale).

It is evident that juices inoculated by *Lactobacillus plantarum* CCM 7039 were different from the others because of a different gustatory quality.

Conclusion

Fermented foods and beverages are defined as products that have been subjected to the effect of microorganisms or enzymes to undergo desirable biochemical changes (Blandino *et al*. 2003). In this work, we prepared lactic acid fermented cabbage juices inoculated with various microorganisms as well as spontaneously fermented cabbage juice. Two strains of *Lactobacillus plantarum* were used for the fermentation of cabbage juices. Lactic acid bacteria are industrially important microbes that are used all over the world in a large variety of industrial food fermentations. Their contribution in these fermentation processes consists primarily of the formation of lactic acid from the available carbon source resulting in a rapid acidification of the unprocessed food material, which is a critical parameter in the preservation of these products. However, apart from their lactic acid forming capacity, lactic acid bacteria also have the ability to contribute to other product characteristics such as flavour, texture and nutrition (Hugenholtz & Smit 2002). The mixed starter culture of *Lactobacillus plantarum* 92H and yeast *Saccharomyces cerevisiae* C11-3 was also applied for the preparation of fermented cabbage juice. The major functions of *Saccaromyces cerevisiae* include the production of alcohols and other aroma compounds, especially esters and organic acids, but other effects may also be seen such as e.g. stimulation of lactic acid bacteria, improvement of nutritional value, probiotic activity, inhibition of mycotoxin-producing mould, and the production of tissue-degrading enzymes (Jespersen 2003).

The results revealed that the most suitable starter culture for cabbage juices was *Lactobacillus plantarum* CCM 7039 (analytical parameters: the highest production of lactic acid, a sufficient decrease of the pH value and increase of the total

acidity, the contents of biogenic amines under the limit of quantification, sensory parameters: the highest intensity of harmonic taste, the acceptance of odour and taste, and the highest intensity of flavour).

We recommend to terminate the fermentation process of cabbage juice inoculated with *Lactobacillus plantarum* CCM 7039 in the 72nd h of fermentation and that of other juices in the 96th h of fermentation because in these fermentation hours: the pH value of juices is sufficiently low to suppress the growth of undesirable microorganisms, the juices contain a sufficient concentration of lactic acid that is a critical preserving agent for the lactic acid fermented products, and the juices have the most suitable sensory attributes.

The principal component analysis shows that, for the maintaining of a sufficient amount of information contained in the original variables, it is essential to determine all the analytical parameters used, all odour descriptors used with the exception of sweet-acid odour, and only some taste descriptors (acid, cabbage, sharp, sweet and harmonic).

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Súhrn

Kohajdová Z., Karovičová J. (2004): **Optimalizácia metódy fermentácie kapustovej šťavy**. Czech J. Food Sci., **22**: 39–50.

Kapustové šťavy sme inokulovali rôznymi mikroorganizmami (*Lactobacillus plantarum* 92H, *Lactobacillus plantarum* CCM 7039, zmesná štartovacia kultúra *Lactobacillus plantarum* 92H a *Saccharomyces cerevisiae* C11-3) a spontánne fermentovali v termostate pri 22 °C počas 168 h. V priebehu fermentácie sme sledovali analytické a organoleptické parametre štiav. Zistili sme, že na fermentáciu kapustových štiav bol najvhodnejší *Lactobacillus plantarum* CCM 7039 (najvyššia produkcia kyseliny mliečnej a dostatočné zníženie pH, najvyššia intenzita harmonickej chute a príjemnosti chute a vône). Kapustové šťavy fermentované zmesnou štartovacou kultúrou alebo spontánne obsahovali na konci fermentácie kadaverín (48,02–78,68 mg/dm^3) a putrescín (82,40–202,95 mg/dm^3). Obsah histamínu a tyramínu bol vo všetkých šťavách pod hranicou limitu stanovenia použitej metódy. Optimálne organoleptické vlastnosti sa dosiahli počas 72 h fermentácie kapustovej šťavy inokulovanej *Lactobacillus plantarum* CCM 7039 a pri ostatných šťavách počas 96 h fermentácie.

Kľúčové slová: fermentácia; kapustová šťava; optimalizácia; organické kyseliny; biogénne amíny; senzorická analýza

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