Mixed Vegetable Juices Acidified with Sauerkraut Juice and Preserved using High Pressure or Heat Pasteurisation Treatments – Nutritional and Sensory Evaluation

Dana GABROVSKÁ[1], Jarmila OUHRABKOVÁ[1], Jana RYSOVÁ[1], Marie HOLASOVÁ[1], Vlasta FIEDLEROVÁ[1], Ivana LAKNEROVÁ[1], Renata WINTEROVÁ[1], Eva EICHLEROVÁ[1], Vladimír ERBAN[1], Jan STROHALM[1], Irena NĚMEČKOVÁ[2] and Milan HOUŠKA[1]

[1]Food Research Institute in Prague, Prague, Czech Republic;
[2]Dairy Research Institute, Ltd., Prague, Czech Republic

Abstract

Gabrovská D., Ouhrabková J., Rysová J., Holasová M., Fiedlerová V., Laknerová I., Winterová R., Eichlerová E., Erban V., Strohalm J., Němečková I., Houška M. (2014): **Mixed vegetable juices acidified with sauerkraut juice and preserved using high pressure or heat pasteurisation treatments – nutritional and sensory evaluation**. Czech J. Food Sci., **32**: 182–187.

The goal of this work was to design mixed vegetable (vegetable-fruit) juices which are preserved by high pressure, have an increased content of bioactive substances, are made from locally available produce, and offer excellent nutrition and appealing taste. The new products were prepared on laboratory scale units and underwent nutritional, microbiological, and sensory evaluations. The basic composition, total polyphenol content, ascorbic acid content, and total antioxidant activity were determined.

Keywords: juice; vegetable; sauerkraut; bioactive substances; microbiological evaluations

The population in the Czech Republic currently lags in the consumption of fruits and vegetables compared with the rest of the European population. The real daily intake of fruits and vegetables is currently far from the recommended daily intake, which is 400 g/day for adults (Dostálová *et al.* 2012).

A variety of available fruit, vegetable or mixed juices is a possible method of increasing the consumption of fruits and vegetables (Dofková *et al.* 2001; Quandir & Akhtar-Danes 2010; Jakubíková *et al.* 2011).

While the availability of fruit juices in the domestic market is acceptable, the availability of vegetable juices is much less acceptable. The products that are available are mainly imported and comparatively expensive.

The range of Czech producers of vegetable juices as well as availability to domestic consumers and for export can be improved by using new vegetable juices. It has been known that for maintaining the stability of juices, acidification of juices is necessary (Kyzlink 1980). Sauerkraut juice is a natural, local, Czech traditional, cheap and available product suitable for the adjustment of juice acidity.

Sauerkraut juice contains glycosides, vitamins A, B_1, B_2, C, K, lactic acid, calcium, phosphorus, iron, sodium, and potassium (On-line Czech Food Composition Database; http://www.czfcdb.cz).

This communication describes the preparation of juices from red beet, celery, parsnip, broccoli, carrot, sauerkraut, and other vegetables that are inexpensive, locally available all the year round and have relatively stable quality (Houška *et al.* 2007; Totušek *et al.* 2011).

The goal of this work was to find appealing combinations of fruits and vegetables for juice produc-

Supported by the Ministry of Agriculture of the Czech Republic, Project No. QI91B089.

tion, to determine their potential storage time and evaluate their nutritional and antioxidant activities. An additional significant goal of this work was to evaluate the potential use of a new method of juice treatment that applies high pressure.

MATERIAL AND METHODS

Materials. A variety of juices were produced under laboratory conditions from the following raw vegetables: red beet (RB), parsnip (PA), cucumber (CU), broccoli (BR), carrot (CA), celery (CE), and garlic (GA). The vegetables and sauerkraut (SK) used for juice preparation were purchased in raw form from the Beskyd Fryčovice, a.s. (Czech Republic).

Preparation of mixed juices. Methods verified during previous research were used for juice preparation, in particular the high pressure treatment methods (Gabrovská *et al*. 2012).

Raw materials were washed and cut to pieces sized for convenient juice pressing with a Champion Juicer (Plastaket MFG. Co. Inc., Lodi, USA). Samples for the high pressure treatment were processed using a 2 l isostatic press (CYX 6/0103 model; Žďas, a.s., Žďár nad Sázavou, Czech Repuvlic).

Nine mixed vegetable juices were prepared and sauerkraut juice was used for acidification. The prepared juices were poured into flexible PET bottles or PA/PE bags, which were then (1) treated using high pressure (410 MPa) for 15 min or (2) heat pasteurized at 85°C for 15 minutes. These conditions were determined by preliminary experiments as sufficient for reaching the good quality products.

The best sensorially evaluated juices were selected for further testing. High pressure treated juices were analysed for nutritional components, microbiologically evaluated and tested for sensory appeal and quality. Two of the heat-pasteurised and one of the high-pressure treated juices were analysed after 30 days of storage at 5°C. Additionally, the pH and refractometric dry matter of the juices were measured.

Nutritional composition. Dry matter content was determined by drying until a constant weight was reached at a temperature of 105°C. Refractometric dry matter was predicted by optical method as °Brix. Protein content was evaluated using the Kjeldahl method (factor for calculation 6.25), ash was evaluated by annealing at 545°C, total polyphenol (TP) content was evaluated using spectrophotometry (Folin-Ciocalteu reagent; measurements were done at a wavelength of 765 nm), vitamin C content (expressed as ascorbic acid – AA) was evaluated using titration with 2,6-dichlorphenolindophenol (Czech standard ISO 6557/2:1984), and antioxidant activity (AOA) was evaluated in methanol extracts of juices using 2,2-diphenyl-1-picrylhydrazyl (DPPH) assays and ferric ion reducing antioxidant power (FRAP) assays.

Saccharide content was calculated from a difference based on the content of water, protein, fat, ash and dietary fibre. Dietary fibre content was determined by enzymatic-gravimetric method (AOAC 991.42). Total energy content was calculated according to Regulation (EU) No. 1169/2011 of the European Parliament and of the Council of 25 October 2011 on the provision of food information to consumers, Annex XIV Conversion factors for the calculation of energy.

Sensory evaluation. Evaluation to determine the consumer appeal was done by twelve evaluators in a specialised laboratory at the Food Research Institute, Prague. Evaluations were assessed using a graphical scale (continuous abscissa having a length of 100 mm). The evaluator indicated the point on the scale corresponding to sweetness or intensity of the evaluated parameter. Sensory acceptability of the products was expressed as an overall impression score. Besides overall impression, appearance, aroma, taste and aftertaste intensity were also evaluated. Results of the evaluations were tested using the Shapiro-Wilk test for normal distribution and outliers were evaluated using the Dean-Dixon (Q) test ($\alpha = 0.05$, $Q_{crit} = 0.392$).

Microbiological evaluation. The microbiological quality of juices, one of the main parameters, was tested after one month of storage at 5°C. The assessment included total count of microorganisms (TCM), yeast (YE), and mould (MO). The total count of microorganisms was carried out using the EN ISO 4833:2013 standard. The standard requires the use of a horizontal counting method for microorganisms, which involves counting colonies grown on a solid medium, under aerobic conditions at 30°C. Yeast and mould were evaluated using the ISO 7954:1987 standard (Microbiology – General guidance for prediction of yeast and mould numbers). The method involves poured plates with selective medium, sample dilutions of known quantities, and aerobic conditions at 25°C for 3, 4, and 5 days.

RESULTS AND DISCUSSION

Results of chemical analysis and nutritional evaluation. The composition, pH and the refractometric dry matter of juices are presented in Table 1. pH of juices without sauerkraut is around 5.5–6.0

Table 1. Composition, pH and refractometric dry matter of juices

Juice No.	Abbreviation	pH	Refractometric dry matter (°BX)	Composition
1	RB/CA/PA/SK	4.6	10.2	red beet/carrot/parsnip/sauerkraut (1:1:1:1)
2	RB/PA/SK	4.6	11.4	red beet/parsnip/sauerkraut (2:2:1)
3	CE/CA/SK	4.9	7.4	celery/carrot/sauerkraut (9.5:9.5:1)
4	RB/CE/CA/SK	4.5	8.0	red beet/celery/carrot/sauerkraut (3:3:3:1)
5	RB/SK	4.6	9.3	red beet/sauerkraut (19:1)
6	RB/CU/SK	4.5	7.4	red beet/cucumber/sauerkraut (9.5:9.5:1)
7	CU/PA/SK	4.6	7.8	cucumber/parsnip/sauerkraut (9.5:9.5:1)
8	CE/CA/RB/SK/GA	4.5	8.0	celery/carrot/red beet/sauerkraut/garlic (1:4:2:2:0.1)
9	BR/PA/CU/SK	4.9	8.3	broccoli/parsnip/cucumber/sauerkraut (2:4:4:1)

(following our measurements). It is apparent from this table that the addition of sauerkraut juice lowered the pH of the juices.

The nutritional quality of the experimentally prepared juices does not show any substantial differences (Table 2). A higher content of saccharides and energy was found in juices with substantial amounts of parsnip juice or red beet juice.

Results of vitamin C, total polyphenols and antioxidant activity analysis are presented in Table 3. Vitamin C showed a low content. The highest values of total polyphenols and antioxidant activity (Table 3)

Table 2. Nutritional evaluation of mixed vegetable juices with sauerkraut juice

Juice No.	Abbreviation	Dry matter (%)	Ash (%)	Protein (%)	Saccharides (%)	Fibre (%)	Energy (kJ/100 ml)
1	RB/CA/PA/SK	9.6	1.3	1.1	6.6	0.6	136
2	RB/PA/SK	11.3	1.4	1.5	7.7	0.7	162
3	CE/CA/SK	7.3	1.2	0.7	4.7	0.7	98
4	RB/CE/CA/SK	8.5	1.1	0.9	5.8	0.7	119
5	RB/SK	10.5	1.1	1.1	7.6	0.7	154
6	RB/CU/SK	6.9	0.8	0.8	4.5	0.7	96
7	CU/PA/SK	7.4	1.1	1.2	4.7	0.4	103
8	CE/CA/RB/SK/GA	8.2	1.1	0.8	5.7	0.6	115
9	BR/PA/CU/SK	7.4	0.9	1.4	4.2	0.9	102

Table 3. Vitamin C, total polyphenols, and antioxidant activity (methods DPPH and FRAP) for mixed juices with sauerkraut juice

Juice No.	Abbreviation	Vitamin C*	TP**	DPPH***	FRAP***
1	RB/CA/PA/SK	1.2	50.6	512.7	498.4
2	RB/PA/SK	4.4	68.7	765.7	754.9
3	CE/CA/SK	< 0.1	39.6	174.9	191.5
4	RB/CE/CA/SK	3.5	56.2	626.9	626.8
5	RB/SK	1.8	90.6	1500.9	1689.8
6	RB/CU/SK	1.0	61.4	563.4	619.2
7	CU/PA/SK	< 0.1	36.5	121.9	175.5
8	CE/CA/RB/SK/GA	0.7	51.2	446.4	487.2
9	BR/PA/CU/SK	4.3	34.5	183.4	260.2

*in mg of ascorbic acid/100 ml; **total polyphenols expressed as equivalent of gallic acid (mg GAE/100 ml); ***in µg AA (ascorbic acid)/1 ml, which has the same antioxidant activity

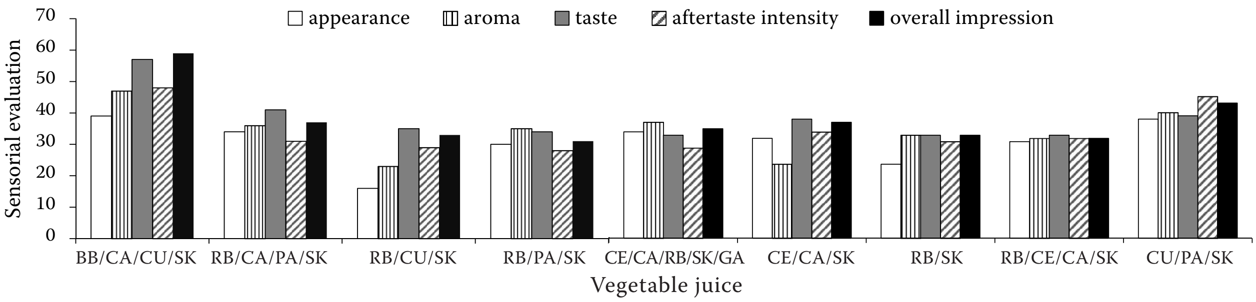

Figure 1. Sensorial evaluation of vegetable juices with testing for outliers using the Dean-Dixon test. The sensory scale includes appearance, aroma, taste, and overall impression: 0 – excellent; 100 – disgusting; intensity of aftertaste; 0 – not present; 100 – very strong)

were found in red beet/sauerkraut juice. High values of these parameters were also found in other red beet containing juices, mainly red beet/parsnip/sauerkraut and red beet/cucumber/sauerkraut juices.

DPPH and FRAP assays showed that the total polyphenol content was well correlated with antioxidant activity (correlation coefficients r = 0.978 and r = 0.962, resp.).

Sensory evaluation. The sensory evaluation of juices was completed in a sensory laboratory over two days. The evaluations of five selected sensory parameters are presented in Figure 1.

The figures show that the best evaluations went to red beet/celery/carrot/sauerkraut, red beet/sauerkraut, red beet/cucumber/sauerkraut, red beet/parsnip/sauerkraut, and celery/carrot/red beet/sauerkraut/garlic.

Microbiological evaluation. Six types of mixed juices treated using high pressure were microbiologically evaluated: red beet/carrot/parsnip/sauerkraut, red beet/parsnip/sauerkraut, celery/carrot/red beet/sauerkraut, red beet/cucumber/sauerkraut, red beet/sauerkraut, and cucumber/parsnip/sauerkraut. These juices were selected as the juices with the nearly best sensory evaluation.

The evaluation was based on assessment of microbial quality parameters such as total count of microorganisms (TCM), yeast (YE) and mould (MO) during storage at 5°C over a 3.5 month period; samples were taken at 0, 31, and 109 days.

The results of this assessment are presented in Figure 2 and show that all tested juices had excellent results, with amounts of yeast and mould below the detection limits of the method used, i.e. less than 1 colony forming unit (CFU/ml) and total count of microorganisms (TCM) between 10^1 up 10^2 CFU/ml after storage. These concentrations easily met the requirements set by Czech standard ČNS 56 9609:2008 (Rules of the correct hygienic practice – Microbiological criteria for foods), in the category "for direct consumption by adults as well as for infants and children."

Two types of mixed juices (CE/CA/RB/SK/GA and BR/PA/CU/SK) were selected for use in a comparison experiment. These juices represent the worst and the nearly best sensorial quality.

The goal of the comparison was to evaluate the influence of the treatment method on the microbial parameters (TCM, yeast and mould) during

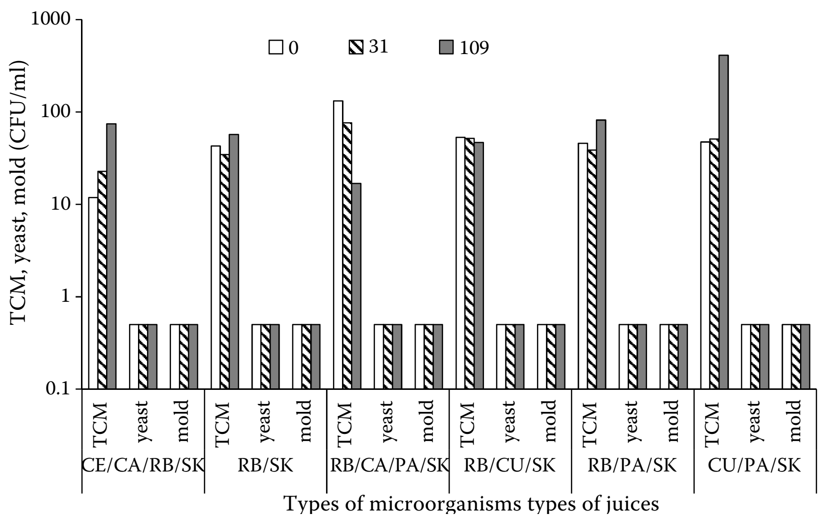

Figure 2. Measurements of total count of microorganisms (TCM), yeast and mould in mixed juices treated using high pressure and stored at 5°C for 31 and 109 days

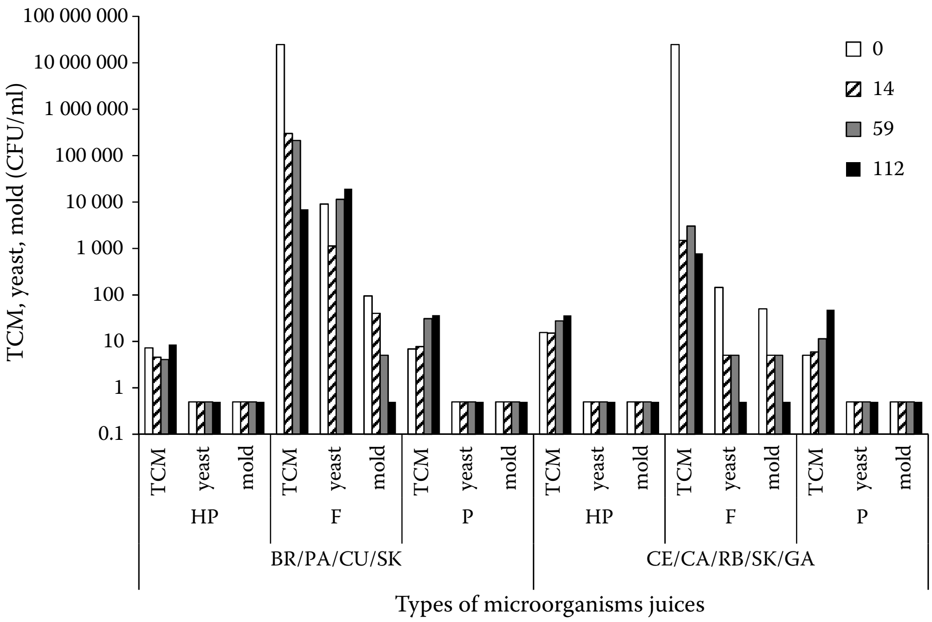

Figure 3. Assessment of total count of microorganisms (TCM), yeast and mould in selected mixed juices (F –fresh, HP – high pressure treated and P – pasteurised) stored at a temperature of 5°C for 0, 14, 59, and 112 days

3.5 months of storage at 5°C; samples were taken at 0, 14, 59, and 112 days. Fresh juices (F), juices treated using high pressure (HP), and heat pasteurised juices at 85°C for 15 min (P) were compared.

The results are presented in Figure 3 and show that there is no significant difference, relative to microbial quality, between juices treated using high pressure and pasteurisation. Values of yeast and mould in both groups were below the measurement limit of the standardised method (less than 1 CFU/ml) and total count of microorganisms (TCM) was generally lower than 10^2 CFU/ml after 3.5 months (112 days) of storage (outliers are also shown in Figure 3). All measured parameters of microbial quality (i.e. total count of microorganisms, yeast and mould) for both mixed juices (CE/CA/RB/SK/GA and BR/PA/CU/SK) regardless of whether they were fresh or after high pressure treatment or heat pasteurization, followed by specified storage conditions and durations met Czech standard ČNS 56 9609:2008 (Rules of the correct hygienic practice – Microbiological criteria for foods), in the category "for direct consumption by adults as well as infants and children."

CONCLUSIONS

Appealing combinations of vegetable-fruit juices using sauerkraut juice as acidifying natural component were suggested. The tested juices (with the exception of juice containing parsnip) contained comparable contents of dry matter and saccharides. The highest contents of total polyphenols were found in juices with the highest red beet content. Juices containing red beet were found to be good sources of antioxidant components. Juices RB/CE/CA/SK, RB/SK and RB/CU/SK reached the highest scores in taste and overall impression. Nutritional and sensory (taste/appeal) evaluation of the proposed juices containing bioactive components showed that it is possible to create appealing and palatable combinations of fruit and vegetable juices, which can be offered in the Czech market or made available for export.

References

Dostálová J., Dlouhý P., Tláskal P. (2012): Nutrition Recommendations for Inhabitants of the Czech Republic. Society for Nutrition, Prague.

Kyzlink V. (1980): Základy konzervace potravin. SNTL, Praha.

Jakubíková M., Dofková M., Ruprich J. (2011): Fruit and vegetable intake in the Czech child population. Public Health Nutrition, **14**: 1047–1054.

Dofková M., Kopřivová V., Resová D., Řehůřková I., Ruprich J. (2001): The development of food consumption in the Czech Republic after 1989. Public Health Nutrition, **4**: 999–1003.

Quandir T., Akhtar-Danes N. (2010): Fruit and vegetables intake in Canadian ethnic populations. Canadian Journal of Dietetic Practice and Research, **71**: 11–16.

Houška M., Strohalm J., Totušek J., Lefnerová D., Tříska J., Vrchotová N., Gabrovská D., Otová B., Gresová P. (2007): Food safety issues of high pressure treated fruit/vegetable juices. High Pressure Research, **27**: 157–162.

Totušek J., Tříska J., Lefnerová D., Strohalm J., Vrchotová N., Zendulka O., Průchová J., Chaloupková J., Novotná P., Houška M. (2011): Contents of sulforaphane and total isothiocyanate, antimutagenic activity, and inhibition of clastogenicity in pulp juices from cruciferous plants. Czech Journal of Food Sciences, **29**: 548–556.

Gabrovská D., Ouhrabková J., Rysová J., Laknerová I., Fiedlerová V., Holasová M., Winterová R., Průchová J., Strohalm J., Houška M., Landfeld A., Erban V., Eichlerová E., Němečková I., Kejmarová M., Bočková P. (2012): New vegetable and fruit-vegetable juices treated by high pressure. High Pressure Research, **32**: 103–113

On-line Czech Food Composition Database. Version 3.12. Available at http://www.czfcdb.cz

Regulation (EU) No 1169/2011 of the European Parliament and of the Council of 25 October 2011 on the provision of food information to consumers, Annex XIV Conversion factors for the calculation of energy.

Received for publication April 8, 2013
Accepted after corrections July 22, 2013

Corresponding author:

Ing. Dana Gabrovská, Ph.D., Výzkumný ústav potravinářský Praha, Radiová 7, 102 31 Praha 10-Hostivař, Česká republika; E-mail: d.gabrovska@vupp.cz