Quality of Cabbage Cultivars Intended for Fermentation in the Ogulin Region

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SUMMARY

Fresh cabbage intended for fermentation should have solid and robust heads with the soluble dry matter content above 3% and light coloured external leaves. Heads are prepared in a 5.5% sodium chloride concentration brine. Biological fermentation proceeds at a temperature of 18-22 °C, in the dark and under anaerobic conditions. The research objective is to find out whether the quality of fresh and fermented cabbage of hybrid cultivars can compete with and replace the cultivar ´Varaždinski´ in the production area of Ogulin. Cabbage ´Varaždinski´ was the predominant and also the referent cultivar, while the other studied cultivars were ´Junior´, ´Kilor´, ´Krautman´ and ´Satellite´ from the Ogulin production area. The quality of fresh raw material during the two trial years was defined by the content of dry matter of 6,63-8,74%, soluble dry matter of 4,0-6,0%, lactic acid of 0,1-0,4%, pH-value of 5,65-6,40, L-ascorbic acid of 151,83-359,11 mg/100 g dry matter and NaCl of 0,09-0,18%. The quality of fermented products during the two trial years was defined by the content of dry matter of 6,00-6,98%, soluble dry matter of 4,97-5,70%, lactic acid of 0,88-1,26%, pH-value of 3,62-4,18, L-ascorbic acid of 63,81-213,23 mg/100 g dry matter and NaCl of 1,53-2,56%. No significant differences between fresh cabbage cultivars were determined by the analysis of variance in the contents of dry matter, soluble dry matter, % of lactic acid, pH value, % of NaCl and L-ascorbic acid. In the first research year, significant differences between cultivars were determined in the content of L- ascorbic acid and the pH value. In the second research year, significant differences were determined in the content of L- ascorbic acid between 60 and 90 days of fermentation.

The results indicate that the cultivar ´Varaždinski´ can be replaced in the Ogulin region by the studied hybrid cultivars.

KEY WORDS

cabbage, fermentation, quality, nutritive value

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INTRODUCTION

Biologically fermented cabbage or sauerkraut is an important foodstuff in Croatia, rich in vitamins and minerals. Sauerkraut is mostly consumed during winter and in early spring months, when the diet is poor in fresh vegetables and the intake of vitamins with food is lower. The lower supply of fresh fruits and vegetables in that period is caused by the seasonal character of production and/or storage under unsatisfactory conditions for particular vegetable species, as well as by smaller market quantities.

Late cabbage cultivars with higher contents of soluble dry matter, and more sugar necessary for good lactic fermentation, are suitable for fermentation. Cabbage heads intended for fermentation should be of appropriate size and firmness, with light, not too green, external leaves.

Characteristics of cabbage production regions, along with different climatic conditions, affect the chemical and sensory quality of the raw material, which is reflected on the durability and quality of end products. Cabbage samples taken to test the fermented product quality came from the production region of Ogulin, which are known as being favourable for cabbage production. Characteristics of the climatic and agroecological conditions of this production region influence the high quality of fresh cabbage and good keeping of the fermented product.

The research objective was to determine the dietary value of fermented products of different cabbage hybrids in comparison with the domestic cultivar, as well as their storage life and the possibility of their mass production. They mature in the part of the year when air temperatures are lower, which makes it easier to control the course of fermentation and maintain storage conditions. Cabbage cultivars of suitable maturing time, intended solely for fermentation, were obtained by breeding (Pavlek, 1985).

Lactic fermentation is the preservation method based on controlled application of some microorganisms, whose activity creates unfavourable conditions for the growth and development of spoilage agents, thereby suppressing their action, and at the same time ensuring the desired quality and improving the product. As this is a controlled process, it requires suitable microorganisms, substrate, temperature, salt concentration, pH and sanitary conditions. Properly conducted fermentation requires a NaCl concentration with selective action upon microorganisms, while cell juice released through osmosis provides sufficient sugar for the development of the desirable microflora. Cabbage heads are fermented in 5,5-6% sodium chloride concentration (Vešnik, 1969a, 1969b; Lovrić and Piližota, 1994; Belitz et al., 1999; Duraković and Duraković, 2001).

The dry matter content of fresh cabbage ranges from 6.1 to 11.10% and of the fermented product ranges from 5,9 to 12,0%, sugar from 2.6 to 5.3% and sauerkraut of 0,8-9,6%, L-ascorbic acid from 13 to 70 mg/100 g fresh raw material and from 54 to 396 mg/kg in the end product, carotene from 0.01 to 0.04 mg/100 g. Cabbage is rich in minerals, notably potassium, sodium, calcium and magnesium. According to literature data, fresh cabbage contains from 0.067 to 0.14% NaCl and sauerkraut from 1.50 to 3,30%. pH values of fresh cabbage ranges from 5,2 to 6,4 and the fermented product range from 3.4 to 3.62, and the end of fermentation occurs at pH from 3.8 to 4.1 with a lactic acid content from 0.5 to 2.50% (Vešnik, 1969a, 1969b; Paula Pavlek, 1985; Niketić, 1988; Lovrić and Piližota, 1994;Lawless and Heymann, 1998;Kalač et al., 1999; Kalač et al., 2000a,2000b; Kalač et al., 2002; Lešić et al., 2002; Viander et al., 2003).

MATERIAL AND METHODS

Cultivars studied were: ´Varaždinski´, as reference cultivar, and hybrid cultivars ´Junior´, ´Kilor´, ´Krautman´ and ´Satellite´, grown at production region of Ogulin, in the years 1999 and 2000.

Fifty uniform cabbage heads of satisfactory firmness, robustness and uniform outer appearance were separated from each cultivar. Fresh raw material was analyzed in the laboratory of the Department of Agricultural Technology, Storage and Transport where its basic chemical composition was determined: % dry matter, % soluble dry matter (refractometrically), % NaCl, % total acidity expressed as lactic acid, pH value and L-ascorbic acid. Heads were cleaned, inner stems were taken out, the mass was weighed on a Mettler 6000D balance and placed into five polyethylene packaging intended for cabbage fermentation. Thus prepared raw material was covered with a solution of water and table salt (concentration 5.5%). The samples were labelled and stored under anaerobic conditions at a temperature maintained at 18 to 22 °C during the first month. Upon the main fermentation, the samples were stored at a temperature of 10 to 15 °C. Fermentation and durability in storage were controlled every thirty days. The basic chemical composition and sensory characteristics of cabbage heads, colour, taste, smell and consistency, were determined. Analyses were performed according to the provisions of the Rulebook on the quality of fruit, vegetable and mushroom products and pectin preparations and its revisions and amendments, and the Rulebook on health criteria for foods and consumer goods in Croatia. Chemical analyses followed the guidelines from the Rulebook on the methods for chemical and physical analyses for quality control of fruit and vegetable products (AOEC, 2002).

Statistical treatment of the data was done by analysis of variance (ANOVA).

RESULTS AND DISCUSSION

Quality of fresh cabbage and of the fermented product is defined on the basis of the results of chemical analyses and sensory characteristics of their taste, colour, smell and consistency. Chemical composition of fresh cabbage (Table 1) was defined by the dry matter values ranging from 6.63 to 8.74%, with average values for both years for particular cultivars: ´Krautman´ 6.70 %, ´Satelite´ 6.99, ´Varaždinski´ 7.02%, ´Kilor´ 7.68% and ´Junior´ 8.09%. Average dry matter content for all cultivars was 7.16% in the first year, and 7.44% in the second year. Values of soluble dry matter ranged from 4.0 to 6.0%, with average values for both years for particular cultivars: ´Krautman´ 4.8%, ´Varaždinski´ 4.99%, ´Satelite´ 5.0%, ´Junior´ 5.15% and ´Kilor´ 5.3%. Average values for all cultivars in the fresh state were 5.78% in the first year and 4.31% in the second year. Average values of lactic acid ranged from 0.1 to 0.4%, with average values for both years for particular cultivars: ´Satelite´ 0.13%, ´Krautman´ 0.23%, ´Junior´ and ´Kilor´ 0.24% and ´Varaždinski´ 0.29%. Average values of all cultivars are 0.28% in the first year and 0.18% in the second year. pH values range from 5.65 to 6.40, with average values for both years for particular cultivars: ´Kilor´ 5.98, ´Varaždinski´ and ´Junior´ 6.23, ´Satelite´ 6.24 and ´Krautman´ 6.31. Average values of all cultivars are 6.08 in the first year and 6.31 in the second year. NaCl contents ranged from 0.09 to 0.18%, with average values for both years for particular cultivars: ´Junior´ 0.10%, ´Kilor´ 0.11%, ´Satelite´ 0.12%, ´Krautman´ 0.13% and ´Varaždinski´ 0.14%. Average values of all cultivars are 0.14% in the first year and 0.10% in the second year. Contents of L-ascorbic acid ranged from 151.83 to 359.11 mg/100g dry matter, with average values for both years for particular cultivars: ´Junior´ 205.9 mg, ´Varaždinski´ 235.62 mg, ´Satelite´ 238.8 mg, ´Kilor´ 263.69 mg and ´Krautman´ 301.38 mg. Average values of all cultivars are 293.45 mg in the first year and 204.70 mg in the second year.

Average values of fresh cabbage chemical properties point to the satisfactory quality of the raw material (Vešnik, 1969a, 1969b; Niketić, 1988; Belitz and Grosch, 1999; Kalač et al., 2000a, 2000b; Lešić et al., 2002). No significant differences between the cultivars were determined by the analysis of variance of the chemical characteristics of fresh cabbage.

In both research years, changes were recorded during fermentation in the contents of dry matter (Table 2) in the range from 6.00% (´Satelite´) to 6.98% (´Kilor´), soluble dry matter, i.e., sugar, (Table 3) from 4.97% (´Satelite´) to 5.70% (Junior) and lactic acid (Table 4) from 0.88% (´Kilor´) to 1.26% (´Junior´). This can be attributed to the separation of cell juice and to anaerobic fermentation causing a different chemical composition of fermented cabbage, which was corroborated by the results of other authors (Vešnik, 1969a, 1969b; Belitz and Grosch, 1999; Kalač et al., 1999; Kalač et al., 2000a, 2000b; Lešić et al., 2002). No significant differences in the contents of dry matter, soluble dry matter and lactic acid were found between fermentations after 30, 60 and 90 days (Tables 2, 3 and 4). No significant differences were determined by testing the mean values of chemical characteristics of particular cultivars either.

Average pH-values (Table 5) after 30, 60 and 90 days of fermentation ranged from 3.62 (´Varaždinski´) to 4.18 (´Kilor´) as a result of the formation of lactic fermentation microflora. The analysis of variance showed significant differences between the cultivars only in 1999. Cultivar ´Kilor´ differs significantly from ´Varaždinski´, ´Krautman´ and ´Satelite´ (**), as well as from ´Junior´ (*). There are no significant differences between the other cultivars.

Table 1. Chemical composition of fresh cabbage

Cultivar	Dry matter (%)	Soluble dry matter (%)	Milk acid (%)	pH	NaCl (%)	L-ascorbic acid (mg/100 g DM)
1999						
Varaždinski	7.12	5.90	0.40	6.10	0.18	243.06
Junior	7.44	5.80	0.30	6.10	0.11	259.97
Kilor	7.67	5.60	0.30	5.65	0.10	359.11
Krautman	6.63	5.60	0.30	6.22	0.16	325.69
Satelite	6.96	6.00	0.10	6.33	0.14	279.43
Average	7.16	5.78	0.28	6.08	0.14	293.45
2000						
Varaždinski	6.92	4.07	0.19	6.35	0.09	228.18
Junior	8.74	4.50	0.19	6.35	0.09	151.83
Kilor	7.69	5.00	0.19	6.30	0.12	168.27
Krautman	6.76	4.00	0.17	6.40	0.09	277.07
Satelite	7.09	4.00	0.17	6.15	0.09	198.17
Average	7.44	4.31	0.18	6.31	0.10	204.70

F-test for the studied characteristics is not significant.

Table 2. Mean dry matter (%)

Cultivar	Days of fermentation			
	30	60	90	Average
1999				
Varaždinski	6.85	6.17	6.37	6.46
Junior	6.23	6.58	6.77	6.53
Kilor	5.84	6.25	6.36	6.15
Krautman	5.92	6.35	6.12	6.13
Satelite	6.26	5.60	6.15	6.00
Average	6.22	6.19	6.35	6.25
2000				
Varaždinski	6.62	7.39	6.25	6.75
Junior	8.24	5.93	6.47	6.88
Kilor	7.21	6.83	6.98	6.98
Krautman	6.53	6.72	6.39	6.55
Satelite	6.45	7.76	6.11	6.77
Average	7.01	6.93	6.44	6.79

F-test for days of fermentation is not significant;
F-test for cultivars is not significant.

Table 3. Mean soluble dry matter (%)

Cultivar	Days of fermentation			
	30	60	90	Average
1999				
Varaždinski	5.40	5.20	5.20	5.27
Junior	5.60	5.00	5.50	5.37
Kilor	5.40	5.70	5.50	5.53
Krautman	5.40	5.50	5.00	5.30
Satelite	5.60	5.50	5.30	5.47
Average	5.48	5.38	5.30	5.39
2000				
Varaždinski	5.00	6.00	5.80	5.60
Junior	6.00	6.00	5.10	5.70
Kilor	6.00	4.00	5.80	5.27
Krautman	5.80	5.00	5.50	5.43
Satelite	5.00	4.00	5.90	4.97
Average	5.56	5.00	5.62	5.39

F-test for days of fermentation is not significant;
F-test for cultivars is not significant.

Table 4. Mean total acids (as % milk acid)

Cultivar	Days of fermentation			
	30	60	90	Average
1999				
Varaždinski	1.80	0.82	0.92	1.18
Junior	1.20	1.25	1.34	1.26
Kilor	0.80	0.92	0.93	0.88
Krautman	1.30	0.83	0.81	0.98
Satelite	1.50	1.03	1.04	1.19
Average	1.32	0.97	1.01	1.10
2000				
Varaždinski	1.11	1.23	1.23	1.19
Junior	0.87	1.37	1.13	1.12
Kilor	1.08	1.16	1.18	1.14
Krautman	1.30	1.32	1.02	1.21
Satelite	1.08	1.21	1.14	1.14
Average	1.09	1.26	1.14	1.16

F-test for days of fermentation is not significant;
F-test for cultivars is not significant.

Table 5. Mean pH

Cultivar	Days of fermentation			
	30	60	90	Average
1999				
Varaždinski	3.68	3.82	3.72	3.74
Junior	3.90	3.82	3.78	3.83
Kilor	4.40	4.08	4.05	4.18
Krautman	3.68	3.62	3.80	3.70
Satelite	3.58	3.81	3.68	3.69
Average	3.85	3.83	3.81	3.83
2000				
Varaždinski	3.62	3.65	3.60	3.62
Junior	3.85	3.72	3.65	3.74
Kilor	3.62	3.62	3.65	3.63
Krautman	3.75	3.60	3.65	3.67
Satelite	3.85	3.58	3.70	3.71
Average	3.74	3.63	3.65	3.67

LSD 0.05 (cultivars, 1999) =0.2424; LSD 0.01 (cultivars, 1999) =0.3525
LSD 0.05 (cultivars, 2000)–n.s;
F-test for days of fermentation is not significant

Table 6. Mean NaCl (%)

Cultivar	Days of fermentation			
	30	60	90	Average
1999				
Varaždinski	2.12	2.69	2.86	2.56
Junior	1.53	1.39	1.67	1.53
Kilor	2.10	2.54	2.61	2.42
Krautman	1.38	2.58	2.61	2.19
Satelite	0.90	2.30	2.96	2.05
Average	1.61	2.30	2.54	2.15
2000				
Varaždinski	1.97	2.28	2.16	2.14
Junior	2.02	1.81	2.22	2.02
Kilor	1.59	2.11	2.41	2.04
Krautman	1.23	1.45	2.33	1.67
Satelite	2.74	1.76	2.05	2.18
Average	1.91	1.88	2.23	2.01

LSD 0.05 (cultivars, 1999) =0.60; LSD 0.01 (cultivars, 1999) =0.87
LSD 0.05 (days, 2000)–n.s; F-test for cultivars is not significant.

NaCl content changed significantly during fermentation (Table 6) after 30, 60 and 90 days only in 1999 because the analysis of variance determined significant differences for 30 and 60 days (*) and for 30 and 90 days (**). No differences between the cultivars were recorded in NaCl contents in either research year.

Average values of L-ascorbic acid (Table 7) in both years ranged from 63.81 mg (´Satelite´) to 221.34 mg (´Krautman´). Significant differences between the cultivars were determined in the first year by the analysis of variance. Cultivars ´Varaždinski´ and ´Satelite´ differed significantly from cultivars ´Junior´ and ´Krautman´ (*), while there were no significant differences between the other cultivars. Significant differences were determined in the second year by the analysis of variance only between 60 and 90 days

Table 7. Mean values of L-ascorbic acid (mg/100 g of dry matter)

Cultivar	Days of fermentation			
	30	60	90	Average
1999				
Varaždinski	100.43	53.32	56.91	70.22
Junior	248.96	296.04	94.70	213.23
Kilor	63.18	233.20	72.97	123.12
Krautman	256.59	235.70	171.73	221.34
Satelite	50.26	75.72	65.45	63.81
Average	143.88	178.80	92.35	138.34
2000				
Varaždinski	89.98	59.00	86.02	78.33
Junior	76.67	49.65	202.75	109.69
Kilor	66.63	73.72	115.77	85.37
Krautman	151.58	83.32	146.51	127.14
Satelite	118.70	88.80	197.79	135.10
Average	100.71	70.90	149.77	107.13

LSD 0.05 (days, 1999) – n.s.
LSD 0.05 (days, 2000) = 48.21; LSD 0.01 (days, 2000) = 70.12
LSD 0.05 (cultivars, 1999) = 109.80; LSD 0.01 (cultivars, 1999) = 159.71

of fermentation (**) while the differences between the cultivars were not significant.

Sensory characteristics (colour, taste, odour and consistency) of fermented cabbage indicated satisfactory quality of all the studied cultivars (not shown).

CONCLUSIONS

The studied cabbage cultivars from the production area of Ogulin displayed good quality of the raw material. Raw material treatment with 5.5% NaCl concentration changed significantly the chemical composition characteristics after 30 days of fermentation. Characteristics of the chemical composition during fermentation from 30 to 90 days rendered satisfactory quality of fermented cabbage.

According to the research results, the studied cultivars give good-quality fresh and fermented cabbage in the Ogulin region and can replace the cultivar ´Varaždinski´.

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