The Possibility of Producing a Special Type of Beer Made from Wort with the Addition of Grape Must

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ABSTRACT

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The possibility of producing a beverage by wort fermentation enriched with grape must was examined. Must, from two different varieties of grapes, was added to conventional brewer's wort. The fermentation was carried out using a traditional method for lager beer production with the entire process taking thirty days. Following the fermentation process, a sensory analysis of the final product was performed and the total polyphenol content was determined. The results obtained suggest that it is possible to produce a pleasant beverage with some sensory properties similar to conventional beer. In addition to acceptable sensory properties, this drink was characterized by a higher alcohol (7–7.5% v/v) and polyphenol content.

Key words: beer, fermentation, grape must, polyphenols.

INTRODUCTION

The effect of beer and wine on consumer health has been studied intensively over the last two decades. The first results, which show that wine consumption has favourable effects on health, were obtained within the MONICA project, a worldwide monitoring system for cardiovascular diseases, organized by the World Health Organization. It was established that moderate wine consumption, red wine in particular, reduces the risk of coronary heart disease by reducing fat accumulation on arteries walls, increasing high density lipoproteins (HDL), and decreasing platelet aggregation. Such a wine effect can be explained by a high content of antioxidants, including resveratrol, which reduces "bad" cholesterol[3]. A great deal of research has shown that beer contains certain useful compounds, such as xanthohumol, isoxanthohumol, 8-prenylnaringenin, ferulic acid, folate, and that it helps in the prevention of diseases such as heart disease, osteoporosis, kidney stones and gallstones, thyroid enlargement, Parkinson's and Alzheimer's disease, dementia, ulcers, some types of cancer, etc.[8,18]

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The positive impact of a moderate intake of wine and beer on cardiovascular disease has been linked to the polyphenol content. Beer polyphenols come mainly from two ingredients used in brewing: malt and hops[7]. Hops provide about 20–30% of beer polyphenols, and the remaining polyphenols originate from the malt[2]. Phenolic components of wine and beer are quantitatively and qualitatively different. Grape contains polyphenols different from those present in the barley and hops used in beer production[7]. Some studies suggest that beer antioxidant activity is strongly correlated with the total polyphenol content[11,16]. There are many references in the literature on determining the total polyphenol content in beer and wine. Red wines contain the highest total phenolic content (1,000–3,000 mg/L), compared with lager beer (312–370 mg/L) and white wine (100–400 mg/L)[5,6,9,10,13].

The absorption of antioxidants by an organism is just as important as their presence in a food and beverage. It has been proven that ferulic acid is much more easily absorbed from beer than tomato, and it has also been shown that, despite the fact that red wine contains a greater proportion of antioxidants, by consuming equal amounts of alcohol from beer and wine, blood contains almost equal amounts of antioxidants[1]. From a nutritional point of view, beer is more abundant in proteins and vitamins compared to wines[12]. Also, beer is a good source of soluble fibre, and significant amounts of soluble dietary fibre are found in beer compared to red and white wine[4].

Each of these beverages has its own advantages and specific features, and the question arises whether one could unite their positive properties. The main objective of this paper was to investigate the possibility of producing a special type of beer by fermenting wort with different proportions of must to produce a product with sensory properties acceptable to the consumer.

MATERIALS AND METHODS

Materials

Must obtained from two different grape varieties was used. Prokupac is a Serbian autochthonous variety, used for making table and top quality rose and red wines, and Muscat Hamburg (Black Hamburg) is a table grape variety with a pleasant taste and a prominent Muscat fragrance, used for producing top quality wines. Grapes,

commercial beer and red wine were purchased from a local market. The wort (70% malt and 30% maize) and a bottom-fermenting yeast used in this study were obtained from a local brewery. Gallic acid, Folin-Ciocalteu's phenol reagent, ammonium hydroxide and sodium carbonate were obtained from Merck (Darmstadt, Germany).

Fermentation

Each of the two grape varieties was used to produce two different final worts, one with a higher and another with lower proportion of must. The grapes were sorted manually, washed in cold water to remove impurities, and the clean grapes were crushed by hand. Maceration was carried out at a temperature of 60°C for 2 h. Wort and must were mixed in specified proportions and the pH was adjusted to 5.2 with ammonium hydroxide. The mixtures of wort and must were sterilized by autoclaving at 105°C for 8 min. The fermentation medium (2 L) was poured into 5 L sterile glass fermenters and seeded aseptically with 100 mL of a yeast suspension, corresponding to 15–20 million yeast cells per millilitre of cold aerated wort. The fermentation process was conducted according to a traditional method for lager beer production and was complete after thirty days. Original gravity of the final worts was in the range of 11.9 to 15.7°P (Table I). Pitching was performed at 7–8°C, the temperature was allowed to rise to 9–10°C. Four days later the beer was slowly cooled to 3–4°C. Afterwards it is transferred into the maturation vessel and cooled slowly to 0°C.

Alcohol, original extract, real extract, degree of fermentation and calories were determined (Alcolyzer Beer ME Analyzing System, Anton Paar, USA).

Sensory evaluation

Following the fermentation, a sensory evaluation of the obtained products was conducted, assessing: fragrance – a sensory attribute resulting from stimulation of the olfactory receptors in the nasal cavity by certain volatile substances (1 – unpleasant, 5 – very pleasant); taste – a sensory attribute resulting from stimulation of the gustatory receptors in the oral cavity by certain soluble substances (1 – unpleasant, 5 – very pleasant); aroma – a combination of olfactory and gustatory attributes perceived during tasting, including tactile, thermal, pain and kinaesthetic effects (1 – unpleasant, 5 –very pleasant); body – the effect of the beer on the inside of the mouth, including the after-palate effect (1 - thin, 2 – watery, 3+4 - full in body, 5 - very full in body); bitterness – a taste that is sharp and acrid and felt with the receptors concentrated towards the back of the tongue and throat (1 – not present, 5 – very strong bitterness); freshness – as determined by the alcoholic strength, CO_2 content and hopping level of the beer (1 – stale, 5 – fresh); general impression – the interaction of all the sensory signals (1 – very bad, 5 – very good). Sensory tests were carried out using a trained panel of 20 members. Students from the University of Belgrade were selected as panellists based on their ability to describe the perceived sensations and to distinguish flavours in beer using ISO 8586-1 (Sensory analysis – General guidance for the selection, training and monitoring of assessors). The age profile ranged from 24 to 30 years. A commercial lager beer was used as a reference for the assessment. The beer samples were evaluated using a 5 point scale. All samples were presented in 250 mL coded transparent drinking glasses covered with a glass top and containing 50 mL beer per glass. Sample were served at 12°C and assessed at room temperature in individual booths illuminated with a red light. The five samples were presented simultaneously in a balanced random order in one session.

Statistical analysis

The experimental results were analyzed with the statistical package STATISTICA v. 6[15]. Homogeneity of variances was analyzed using the Levine's test. In accordance with the results of this test, the significance of the difference of average grades of sensory properties of beers was tested with the student's t-test for dependent samples or the Wilcoxon matched pairs test.

Total phenolic content (TPC)

The total phenolic content of samples was determined according to the Folin-Ciocalteu spectrophotometric method[14]. Samples of beer (0.1 mL) were mixed with 0.9 mL of distilled water and 5 mL of 10-fold diluted Folin-Ciocalteu's phenol reagent and allowed to react for 5 min. Four millilitres of saturated sodium carbonate (75 g/L) was added to the mixture and then shaken. After 2 h of reaction at room temperature, the absorbance at 760 nm was determined. The measurement was compared to a calibration line of prepared gallic acid (GA) solution, and the results were expressed as milligrams of gallic acid equivalents per litre of beer (mg GAE/L). All determinations were performed in triplicate.

Table I. Physico-chemical properties of beers.

Parameter	Cb[a]	Pl[b]	Ph[b]	Hl[c]	Hh[c]
Original extract (° Plato)	11.9	14.1	15.4	14.3	15.7
Real extract (% [w/w])	2.80	3.62	4.46	3.79	3.96
Real degree of fermentation (%[w/w])	77.60	75.80	72.80	75.25	75.94
Alcohol (% [v/v])	5.00	6.95	7.36	7.00	7.48
Calories (kJ/100 mL)	148	213	235	216	238
IBU	27	26	24	26	25
Colour (EBC units)	5.9	27.1	30.4	24.8	28.3
pH	4.59	4.36	4.28	4.43	4.38
CO_2 (g/L)	4.98	6.03	6.18	6.11	6.23

[a] Commercial beer.
[b] Beer with lower (Pl) and higher (Ph) proportions of Prokupac must.
[c] Beer with lower (Hl) and higher (Hh) proportions of Muscat Hamburg must.

RESULTS AND DISCUSSION

The physico-chemical characteristics of the beers are shown in Table I. In general, the alcohol levels and original extracts were higher in beers produced with grape must than in the commercial beer. The real degree of fermentation was slightly higher in the commercial beer, but the real extract was much higher in the beers with the added grape must. In addition, the fermentation kinetics of the mixture composed of wort and grape must was different from the fermentation of pure wort. At the beginning, the fermentation rate of the mixture composed of wort and grape must was more rapid, probably due to higher concentration of glucose originating from the must. After two days, the fermentation rate of the mixture was similar to the fermentation rate of pure wort (Fig. 1).

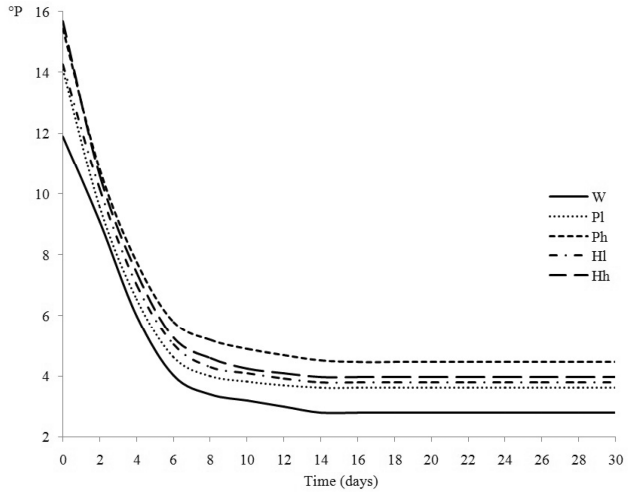

Fig. 1. Fermentation profiles (gravity vs. time). (W – Pure wort, Pl, Ph – Beer with lower and higher proportions of Prokupac must, Hl, Hh – Beer with lower and higher proportions of Muscat Hamburg must).

Regarding data series, homogeneity (Cv<30%) and results of Levene's Test for Homogeneity of Variances, significance of grades difference for analyzed sensory properties were tested by t-test for dependent samples and Wilcoxon Matched Pairs Test. The results of the sensory evaluation are presented in Table II and Table III.

Obtained products had very interesting and specific sensory characteristics. Fragrance of beers produced by fermentation of wort and must of Prokupac grape (Pl – beer with a lower proportion of Prokupac must and Ph – beer with a higher proportion of Prokupac must) were more variable. Mean values were slightly lower than those for standard beer, but did not differ statistically. The taste, aroma and body of these samples did not differ statistically from the standard beer. Mean values of both samples were lower than standard mean values, with the exception of body, where the sample Pl received a slightly higher grade. Both beers with the addition of the Prokupac must had a significantly lower intensity of bitterness, whereas their freshness was at the same level as the standard beer.

Table II. Results of statistical tests for beer samples with lower and higher proportions of Prokupac must.

			Statistical tests					
			Levene's		t-test		Wilcoxon-test	
Sensorial property	Type of beer	Mean	F[a]	p[b]	t[a]	p	Z[a]	p
Fragrance	Cb[c]	3.61	3.417	0.018	-	-	0.714	0.476
	Pl[d]	3.43						
	Cb	3.61	7.606	0.011	-	-	0.133	0.894
	Ph[d]	3.57						
Taste	Cb	3.75	0.067	0.797	0.618	0.547	-	-
	Pl	3.61						
	Cb	3.75	4.377	0.046	-	-	0.942	0.346
	Ph	3.36						
Aroma	Cb	3.68	0.020	0.890	0.151	0.883	-	-
	Pl	3.64						
	Cb	3.68	3.527	0.072	0.758	0.462	-	-
	Ph	3.39						
Body	Cb	3.39	0.004	0.950	–1.608	0.132	-	-
	Pl	3.82						
	Cb	3.39	0.152	0.699	0.278	0.786	-	-
	Ph	3.29						
Bitterness	Cb	4.00	0.020	0.889	2.259	0.042	-	-
	Pl	3.46						
	Cb	4.00	0.150	0.701	2.314	0.038	-	-
	Ph	3.11						
Freshness	Cb	3.93	0.783	0.384	0.000	1.000	-	-
	Pl	3.93						
	Cb	3.93	0.685	0.415	0.360	0.724	-	-
	Ph	3.82						
General impression	Cb	3.86	0.028	0.868	0.751	0.466	-	-
	Pl	3.68						
	Cb	3.86	4.871	0.036	-	-	1.161	0.245
	Ph	3.36						

[a] F, t and Z – Sample values applied tests.
[b] Level of significance ($p \leq 0.05$ difference is significant).
[c] Commercial beer.
[d] Beer with lower (Pl) and higher (Ph) proportions of Prokupac must.

General impressions of the samples did not differ statistically.

The fragrance, aroma and body of the beers with the higher content of Muscat Hamburg (Hh) were statistically significantly better than the fragrance, aroma and body of the commercial beer, whereas according to the other parameters they did not statistically differ. However, the sample Hh received higher average grades for every characteristic that was assessed. The beer with a lower content of Muscat Hamburg (Hl) received slightly lower grades than the standard beer, but statistically the grades did not differ.

Statistical analysis of the sensorial grades showed that by fermentation of wort with certain proportion of must it was possible to obtain a product with a satisfactory sensory property, which could be acceptable and even better than a common commercial lager beer. The beer with a higher content of Muscat Hamburg was distinguished from the rest of the assessed beers by obtaining higher grades than the commercial beer in each parameter tested. Moreover, for certain parameters the differences between these two beers were statistically significant. The beer was characterized by a pleasant Muscat, flower-fruit fragrance, enjoyable aroma and high smoothness of taste, with prominent freshness and good after-taste. The content of alcohol was higher at 7% v/v.

Phenolic compounds are generally considered as one of the very important antioxidant sources in beer, and beer antioxidant activity is strongly correlated with the total phenolic content[11,16,17]. The content of total phenolic compounds determined by the Folin-Ciocalteau method for the analyzed samples is shown in Table IV. In the red wine, the total amount of the phenolic compounds was significantly higher than in the other samples. The amount of total phenolic compounds decreased in the following order: red wine, beer with the higher content of Prokupac must, beer with the higher content of Muscat Hamburg must, beer with the lower content of Prokupac must, beer with the lower content of Muscat Hamburg must and the lowest values were found in commercial beer. The results for the commercial beer and red wine are in agreement with those reported in the literature[5,6,9,10,13].

Table IV. Total phenolic content (TPC)[a].

Sample	TPC (mg GAE/L) ± SD
Commercial beer	319.4 ± 12.3
Pl[b]	346.2 ± 16.4
Ph[b]	406.5 ± 20.6
Hl[c]	384.8 ± 9.1
Hh[c]	432.6 ± 11.3
Red wine	1405.9 ± 56.7

[a] Values are means ± SD of triplicate determinations.
[b] Beer with lower (Pl) and higher (Ph) proportion of Prokupac must.
[c] Beer with lower (Hl) and higher (Hh) proportion of Muscat Hamburg must.

Table III. Results of statistical tests for beer samples with lower and higher proportions of Muscat Hamburg must.

Sensorial property	Type of beer	Mean	Statistical tests					
			Levene's		t-test		Wilcoxon-test	
			F[a]	p[b]	t[a]	p	Z[a]	p
Fragrance	Cb[c]	3.61	1.551	0.224	–0.168	0.869	-	-
	Hl[d]	3.64						
	Cb	3.61	0.017	0.897	–2.347	0.035	-	-
	Hh[d]	3.96						
Taste	Cb	3.75	0.006	0.940	1.669	0.119	-	-
	Hl	3.36						
	Cb	3.75	0.000	1.000	–1.073	0.303	-	-
	Hh	4.00						
Aroma	Cb	3.68	0.225	0.639	0.434	0.671	-	-
	Hl	3.61						
	Cb	3.68	0.657	0.425	–2.197	0.047	-	-
	Hh	4.11						
Body	Cb	3.39	0.135	0.716	0.291	0.775	-	-
	Hl	3.32						
	Cb	3.39	0.614	0.440	–2.414	0.031	-	-
	Hh	3.86						
Bitterness	Cb	4.00	2.186	0.151	1.835	0.089	-	-
	Hl	3.57						
	Cb	4.00	1.098	0.304	0.154	0.880	-	-
	Hh	3.96						
Freshness	Cb	3.93	1.112	0.301	0.434	0.671	-	-
	Hl	3.82						
	Cb	3.93	0.430	0.518	–1.529	0.150	-	-
	Hh	4.21						
General impression	Cb	3.86	0.019	0.892	1.385	0.189	-	-
	Hl	3.64						
	Cb	3.86	0.004	0.950	–0.862	0.404	-	-
	Hh	4.04						

[a] F, t and z – sample values applied tests.
[b] Level of significance ($p \leq 0.05$ difference is significant).
[c] Commercial beer.
[d] Beer with lower (Hl) and higher (Hh) proportions of Muscat Hamburg must.

CONCLUSIONS

The results obtained suggest that it is possible to produce a special type of beer made from wort and grape must with very interesting and pleasant sensory properties. The unique flavour of these beers might be of interest to consumers. These beers were characterized by an increased alcohol and real extract content, with sensory properties similar to conventional beer, but with some peculiarities. The results obtained in this study are encouraging for further research and indicate the possibility of obtaining a range of special beers with different sensory properties and increased functionality.

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