INFLUENCE OF QUINCE VARIETY ON ALCOHOL CONTENT AND QUALITY OF SPIRIT

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Some of the specific characteristics of quince fruits, such as the high content of pectin substances and relatively low content of fermentable sugars, lead to certain challenges during alcoholic fermentation. The aim of this research was to evaluate the effect of quince variety on fermentation dynamics, alcohol yield and chemical composition of produced spirits. Nine quince varieties grown at the experimental field “Radmilovac” (University of Belgrade - Faculty of Agriculture), were used in this study: Vranjska (SRB), Leskovačka (SRB), Morava (SRB), Pazardžijska (BLG), Hemus (BLG), Asenica (BLG), Portugal (POR), Triumph (BLG) and Rea’s Mammoth (USA). The investigation was carried out in 2018. Soluble solids content in quince fruits was in the range from 12.90% (Pazardžijska) to 16.80% (Morava). Total sugars and total acids expressed as malic acid were in the range from 6.74 % and 0.53% w/w (Pazardžijska) to 9.76 % and 1.27% w/w (Morava), respectively. The highest alcohol content had spirits made from quince varieties Leskovačka and Asenica (9.88 litres of 40% vol. alcohol from 100kg of fruit), while the lowest alcohol content had spirit made from variety Rea’s Mammoth (7.20 litres of 40% vol. alcohol from 100 kg of fruit). All spirit samples had methanol content (up to 1350 g/hl, calculated at 100% of alcohol) and other quality parameters in accordance with the legal regulations.

Keywords: quince spirit, spirit quality, alcohol content, methanol, volatile compounds

Introduction

In Serbia, 12.556 tons of quince are produced annually (this data is the average value from the period 2015–2017), which presents 3% of the global quince production. Because of this high quince production, Serbian quince production is in the 4th place among European countries and in the 9th place at a global level [1]. Quince production in Serbia is primarily done in small production areas. The centre of production (71 %) is located in central Serbia, while the rest of the production is done in the northern parts of the country. The most important locations for quince production in Serbia are Leskovac and Vranje surroundings, Podunavlje, Velika and Zapadna Morava [2,3].

The processing industry showed a trend of an increasing need for quince fruits in order to make different products, but mainly quince-based beverages. This resulted in a significant increase in quince production in Serbia. The main cultivar grown in Serbia is Leskovacka, aromatic quince with high-quality fruits. The most abundant pollinator grown in quince orchards is the cultivar Vranjska.

Quince is characterized by very attractive and high-quality fruits. Quince fruit contains carbohydrates, primarily monosaccharides and organic acids which give the fruit its specific aroma and refreshing taste. In addition, quince fruits are rich in tannins, minerals and vitamins [2,4].

Analysis of the edible part of the quince fruit indicates that it contains on average 84.6% water, 14.2% dry matter, 9.0% total and 5.0% reducing sugars, then 1.8% pectin, 0.8% tannin, 16.8 mg/100 g ascorbic acid, etc. [5]. The quality of the fruit varies depending on the genotype, geographical origin, climatic conditions, position of the fruit on the branch, harvesting time and cultivation technology [6]. The main products made from quince are compotes, jams, juices and jellies. In recent years, quince alcoholic beverages became important as their specific aroma is appreciated by consumers [3,7,8].

Quince spirit is produced by distillation and/or rectification of the fermented quince mash or quince juice, with or without seeds, up to 86% vol. alcohol, so that

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the taste and aroma of distillate originate exclusively from the fruit [9].

New breeding programs resulted in new quince cultivars which provide good yields followed by great fruit quality. Among fruit quality traits, chemical compounds like acids, soluble solids and sugars are very much important for quince quality. Also, aromatic compounds present an important quality trait of the cultivar [10].

In addition to the production properties, it is crucial to evaluate the physical and chemical properties of the fruit, as well as their suitability for processing, especially regarding the production of alcoholic beverages.

The aim of this study was to examine the effect of quince variety on fermentation dynamics, alcohol yield and chemical composition of produced spirits.

Materials and methods

Materials

This study was carried out in 2018. using quince from the test orchard of the experimental field „Radmilovac“, Faculty of Agriculture, University of Belgrade. ‘QuinceMA’ was used for quince rootstock while the training system was modified central leader. In this study, nine cultivars of quince were used: Vranjska (SRB), Leskovačka (SRB), Morava (SRB), Pazardžijska (BLG), Hemus (BLG), Asenica (BLG), Portugal (POR), Triumph (BLG) and Rea’s Mammoth (USA).

Selected yeast *Saccharomyces cerevisiae* train Actiflore®BO213 was purchased from Laffort, France. Enzyme Enartis Zym RS with strong pectolytic and hemicellulase activities was obtained from Enartis, South Africa. A fermentation activator containing nutritive elements that promote yeast multiplication (Nutristart®) and mineral salt diammonium phosphate was procured from Laffort, France. Citric acid was purchased from a local market.

Methods

The experiments included the physical, sensory and chemical characteristics of the fruit, as well as fermentation kinetics, alcohol yield and chemical quality parameters of fruit spirits.

Fruit weight was measured on a precision balance with a precision of 0.01 g. For the fruit dimension`s measurement, a digital calliper was used. The calculation of the fruit shape index was based on the dimensions of the fruit. Fruit firmness was measured by a penetrometer (Facchinisrl, Italy) and expressed in kg cm^{-2}.

A digital handheld refractometer (Atago, Pocket PAL-1) was used for total soluble solids measurement. Total and inverted sugar content was examined by the Luff-Schoorl method [11].

The difference between total and inverted sugar was multiplied by a coefficient of 0.95, in order to calculate sucrose content. Total acidity was measured by titration method, based on 0.1N NaOH titration, until the colour change of the indicator phenolphthalein [12].

Five-member jury performed a sensory analysis of the fruits (attractiveness, taste, aroma, bitterness and juiciness) using the scoring method.

Spirit production. After harvesting, quince fruits were left for ripening in fruit crates for 14 days at a temperature of 16 °C. When the quince had reached an adequate degree of maturity, fruits were weighed (25 kg), washed and crashed. The obtained fruit mash is mixed with 15 kg of warm water (50 °C) and 1.25 g of pectolytic enzyme Enartis Zym RS. The goal of adding enzymes is to liquefy the fruit mash and facilitate the extraction of fermentable sugars. Alcoholic fermentation was done using the selected yeast *Saccharomyces cerevisiae* strain Actiflore®BO213. At the beginning of fermentation, mineral nutrient for yeast (diamonium phosphate, 200 g/t) was added. Organic nutrient (Nutristart, 200 g/t) is added after three days. The pH value of the mash was adjusted to 3.4±0,1 with 10% w/v citric acid solution. During fermentation, total soluble solids and pH were monitored. After fermentation lasting for 15 days, double distillation is conducted. The first distillation yielded distillates of 21-26% vol. alcohol, while the second distillation yielded distillates of 60.6 – 62.2% vol. alcohol, where 1% of the head fraction was separated.

Ethanol content was determined by a digital density meter (DMA 4500, Anton Paar, Austria). The chemical composition of the final distillates was obtained with the gas chromatography method (7890B GC System, Agilent Technologies, USA) (Commission Regul. EC No.2870/2000).

Results and discussion

Physical properties of the fruit

Fruit weight is a very important characteristic of the yield and quality of quince fruit. It varied between varieties from 216.7 g (Leskovačka) to 448.7 g (Morava) (Table 1). Varieties Leskovačka and Pazadržijska had small fruits (below 300 g), varieties Vranjska, Hemus, Asenica, Portugal and Rea’s Mammoth medium-sized fruits (300-400 g) and varieties Morava and Triumph large fruits (over 400 g). The fruit weight in this study was in relation with the results of Legua et al. [13]. It is positively correlated with fruit yield and dimensions [14].

Table 1. Physical properties of the fruit

Quince variety	*Fruit weight (g)*	*Fruit length (mm)*	*Fruit width(mm)*	*Fruit shape index*	*Fruit firmness (kg/cm²)*
Vranjska (SRB)	311.7	91.8	85.0	1.08	6.6
Leskovačka (SRB)	216.7	66.3	80.2	0.83	7.7
Morava (SRB)	448.7	93.7	95.9	0.98	6.7
Pazardžijska (BLG)	265.1	77.8	83.9	0.93	4.7
Hemus (BLG)	317.9	83.3	87.0	0.96	7.2
Asenica (BLG)	311.9	82.8	86.3	0.96	6.9
Portugal (POR)	372.6	93.4	89.6	1.04	7.2
Triumph (BLG)	421.9	84.5	94.3	0.90	5.3
Rea’s Mammoth (USA)	331.9	100	85.4	1.17	6.7

By the fruit weight, a variety Leskovačka had the smallest dimensions of the fruit (length – 66.3mm and width – 80.2 mm). The largest fruit length had the variety Rea's Mammoth (100mm), and the largest fruit width had the variety Morava (95.9mm) and Triumph (94.3 mm). Based on the dimensions of the fruit, the fruit shape index was calculated. The variety Rea's Mammoth had the highest shape index (1.17), and the lowest had the variety Leskovačka (0.83). After analysing the shape of the fruit, it can be stated that the varieties Vranjska and Rea's Mammoth had an elongated fruit shape, the varieties Leskovacka and Triumph slightly flattened shape, while in other varieties the fruit shape was round (fruit shape index approx. 1). The varieties with round or slightly flattened shape fruits are more suitable for processing compared to the varieties with elongated fruit. Fruit firmness is an important technological feature, on which the suitability of fruits for processing depends. It is desirable that quince fruits are less firm because they are more suitable for processing. It is positively correlated with pectin and calcium content in fruits [15]. Varieties Pazadržijska and Triumph are less firm (4.7 and 5.3 kg cm^{-2}, respectively), which makes them potentially the most suitable for processing. On the other hand, varieties Leskovačka and Portugal are more firm (7.7 and 7.2 kg cm^{-2}, respectively). The quince varieties in our study had lower fruit firmness compared to the results found by Legua et al. [13], which makes them more suitable for processing.

Chemical properties of the fruit

The chemical composition of quince fruit is the most important parameter of their quality. The total soluble solids of the fruit depend largely on the degree of fruit ripeness. It gradually increases with an increasing degree of fruit maturity [16]. In our experiment, the total soluble solids varied from 12.90% (Pazardžijska) to 16.20% (Leskovačka) and 16.80% (Morava) (Table 2). Varieties Leskovačka and Morava had a higher amount of soluble solids than the results obtained by Rop et al. [4] in the Czech Republic, which can be explained by more favourable agroecological conditions for growing in our country.

Table 2. Chemical properties of the fruit

Quince variety	*Soluble solids (%)*	*Total sugars (%)*	*Inverted sugars (%)*	*Sucrose (%)*	*Total acids (%)*
Vranjska (SRB)	15.20	8.34	7.41	0.88	0.71
Leskovačka (SRB)	16.20	9.15	8.28	0.83	0.99
Morava (SRB)	16.80	9.76	8.81	0.92	1.27
Pazardžijska (BLG)	12.90	6.74	5.72	0.97	0.53
Hemus (BLG)	13.20	7.21	6.07	1.08	0.59
Asenica (BLG)	15.80	8.73	7.84	0.85	0.77
Portugal (POR)	15.40	8.51	7.46	0.99	0.81
Triumph (BLG)	15.00	8.41	7.33	1.03	0.71
Rea's Mammoth (USA)	14.60	8.12	7.27	0.81	1.09

Sugar content was consistent with total soluble solids. Thus, the highest content of total and inverted sugars was found in varieties Morava (9.76 and 8.81%, respectively) and Leskovačka (9.15 and 8.28%, respectively), and the lowest content was found in variety Pazardžijska (6.74 and 5.72%, respectively). Sucrose content was highest in varieties Hemus (1.08%) and Triumph (1.03%) and the lowest was in the variety Rea's Mammoth (0.81%).

In addition to soluble solids and sugar content, the content of total acids is a very important parameter of fruit quality. The taste and aroma of quince fruit depend more on the soluble solids/total acids ratio than on the total soluble solids or total acids considered independently [17]. The highest total acids content was found in the variety Morava (1.27%), and the lowest in the variety Pazardžijska (0.53%). Fruits with low acid content decay faster and are preserved less, so they must be processed quickly after harvest. The acid content in our study was higher and varied more between varieties compared to the results obtained by But and Klimenko [18]. The genotype has a significant effect on the manifestation of these differences [4].

Sensory properties of the fruit

Along with physical and chemical characteristics, sensory properties are also an important parametre of the quality of quince fruit. Compared to the other types of fruit, quince fruits are characterized by specific sensory attributes. They are known by their strong aroma. In our study, sensory properties were consistent with the chemical composition of the fruit (Table 3).

Table 3. Sensory properties of the fruit

Quince variety	*Attractiveness (1-10)*	*Taste (1-10)*	*Aroma (1-10)*	*Astringency (1-3)*	*Juiciness (1-3)*
Vranjska (SRB)	6.0	5.5	5.5	2.0	2.0
Leskovačka (SRB)	7.0	6.0	6.0	2.0	1.0
Morava (SRB)	10.0	10.0	8.0	1.0	3.0
Pazardžijska (BLG)	4.0	4.5	4.5	1.0	1.5
Hemus (BLG)	8.0	6.5	7.0	1.0	1.8
Asenica (BLG)	7.0	8.0	7.5	2.0	1.8
Portugal (POR)	6.0	7.3	6.5	2.0	1.0
Triumph (BLG)	8.0	7.0	6.5	1.0	3.0
Rea's Mammoth (USA)	5.0	7.5	8.0	2.0	1.0

The Morava variety received the maximum score for the appearance and taste of the fruit (10.0), and along with the variety Rea's Mammoth, it also had the most aromatic fruits (8.0). The worst-scored variety in terms of sensory characteristics was Pazardžijska (appearance – 4.0; taste and aroma – 4.5).

Astringency and juiciness are characteristics that were rated with a score of 1 – 3. The astringency of quince fruits is related to the tannin content. Astringency level in the varieties Morava, Pazardžijska, Hemus and Triumph was low (1.0), and among the other varieties, it was moderate (2.0). Varieties like Morava, Hemus, Triumph and Pazardžijska are suitable for fresh consumption [13]. Juiciness is an important feature of fruit freshness. Varieties Morava and Triumph had the juiciest fruits (3.0), while the fruits from varieties Portugal and Rea's Mammoth were dry (1.0). Varieties that are less astringent and juicier are suitable for fresh consumption.

The dynamics of fermentation were monitored by changes in total soluble solids (TSS) and pH values

(Tables 4 and 5). The initial TSS in different varieties of quince varied from 12.9 (Pazadžijska) to 16.8 ºBx (Morava) (Table 4). The high decrease on the first day is not due to the fast start of fermentation, but due to the added water during the fruit processing. The reason for the increase during the second day is the increased extraction of sugar from the fruit tissue. At the same time, induced alcoholic fermentation by the selected yeast strain *Saccharomyces cerevisiae* began.

Table 4. Soluble solids content during 15 days of alcoholic fermentation

Quince variety	°Bx Fruit	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Vranjska (SRB)	15,2	10,0	11,2	9,5	7,5	6,5	6,1	5,8	5,8	5,8	5,8	5,8	5,8	5,8	5,8	5,8
Leskovačka (SRB)	16,2	12,0	13,0	11,8	8,0	7,3	7,0	6,5	6,3	6,1	6,1	6,1	6,1	6,1	6,1	6,1
Morava (SRB)	16,8	11,0	12,2	11,2	7,3	6,5	6,0	5,9	5,9	5,9	5,9	5,9	5,9	5,9	5,9	5,9
Pazardžijska (BLG)	12,9	10,0	10,9	10,0	6,2	5,5	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0
Hemus (BLG)	13,2	11,1	12,0	11,5	7,9	6,9	6,4	6,0	6,0	6,0	6,0	6,0	6,0	6,0	6,0	6,0
Asenica (BLG)	15,8	10,9	12,1	11,0	7,8	7,1	6,8	6,1	6,0	6,0	6,0	6,0	6,0	6,0	6,0	6,0
Portugal (POR)	15,4	10,0	12,0	10,0	7,3	6,9	6,4	5,9	5,9	5,9	5,9	5,9	5,9	5,9	5,9	5,9
Triumph (BLG)	15,0	10,7	11,9	10,2	7,3	6,8	6,4	5,9	5,9	5,8	5,8	5,8	5,8	5,8	5,8	5,8
Rea´s Mammoth (USA)	14,6	10,7	11,9	10,2	7,3	6,8	5,4	5,4	5,4	5,4	5,4	5,4	5,4	5,4	5,4	5,4

The pH value can also be an important parameter for alcoholic fermentation monitoring. Before alcoholic fermentation, citric acid was added to slightly decrease the pH value of the mash, to prevent its spoilage. During alcoholic fermentation, there are small changes in pH value, which indicates the activity of the yeast (Table 5).

Table 5. Changes in pH value during 15 days of alcoholic fermentation

Quince variety	pH 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Vranjska (SRB)	3.40	3.40	3.36	3.36	3.33	3.33	3.36	3.36	3.42	3.41	3.41	3.45	3.42	3.41	3.42
Leskovačka (SRB)	3.49	3.50	3.40	3.33	3.30	3.39	3.40	3.44	3.43	3.39	3.39	3.48	3.43	3.39	3.43
Morava (SRB)	3.41	3.41	3.40	3.40	3.30	3.38	3.38	3.40	3.34	3.33	3.32	3.38	3.34	3.33	3.34
Pazardžijska (BLG)	3.51	3.48	3.48	3.41	3.41	3.41	3.44	3.48	3.35	3.35	3.34	3.37	3.35	3.35	3.35
Hemus (BLG)	3.46	3.46	3.46	3.40	3.37	3.35	3.38	3.39	3.39	3.37	3.37	3.42	3.39	3.37	3.39
Asenica (BLG)	3.46	3.46	3.46	3.39	3.37	3.37	3.37	3.39	3.36	3.35	3.34	3.36	3.36	3.35	3.36
Portugal (POR)	3.33	3.30	3.25	3.25	3.25	3.29	3.34	3.36	3.37	3.35	3.40	3.30	3.37	3.35	3.37
Triumph (BLG)	3.41	3.40	3.40	3.40	3.41	3.36	3.37	3.38	3.42	3.42	3.39	3.43	3.42	3.42	3.42
Rea´s Mammoth (USA)	3.50	3.50	3.45	3.40	3.39	3.42	3.44	3.44	3.40	3.30	3.34	3.46	3.40	3.30	3.40

The alcohol yield is shown in table 6. The results show that spirits made from quince varieties Leskovačka and Asenica have the highest alcohol content (9.88 litres of 40% vol. alcohol from 100 kg of fruit), while the lowest alcohol content has quince spirit made from the variety Rea's Mammoth (7.20 litres of 40% vol. alcohol from 100 kg of fruit) (Table 6).

Table 6. Date of harvest, fermentation and distillation (2018) and alcohol yield of obtained distillates

Quince variety	Date of harvest	Amount of fruits (kg)	Ripening duration (days)	Beginning of alc. fermentation	Duration of alc. fermentation (days)	Beginning of distillation	First distillate yield (liters)	Alcohol yield of first distillate (alk. %vol)	Second distillate yield (liters)	Alcohol yield of second distillate (alk. %vol)	40,0% vol quince spirit yield (liters)	40,0% vol quince spirit yield, calculated at 100kg of fruits (liters)
Vranjska (SRB)	10.10.	25	14	24.10.	15	08.11.	4.56	24.0	1.55	61.0	2.36	9.44
Leskovačka (SRB)	10.10.	25	14	24.10.	15	08.11.	4.56	25.0	1.60	61.7	2.47	9.88
Morava (SRB)	10.10.	25	14	24.10.	15	08.11.	5.15	21.0	1.50	62.2	2.33	9.32
Pazardžijska (BLG)	10.10.	25	14	24.10.	15	08.11.	3.63	26.0	1.33	60.7	2.02	8.08
Hemus (BLG)	10.10.	25	14	24.10.	15	08.11.	3.58	24.0	1.20	60.9	1.83	7.32
Asenica (BLG)	10.10.	25	14	24.10.	16	09.11	4.57	25.0	1.60	61.8	2.47	9.88
Portugal (POR)	10.10.	25	14	24.10.	16	09.11	3.80	23.0	1.23	60.6	1.86	7.44
Triumph (BLG)	10.10.	25	14	24.10.	16	09.11	4.13	26.0	1.51	61.4	2.32	9.28
Rea´s Mammoth (USA)	10.10.	25	14	24.10.	16	09.11	3.54	24.0	1.16	62.2	1.80	7.20

All compounds of the chemical composition of the final distillates were within a legal range, according to the Law on Spirit drinks in Serbia [19].

Volatile compounds include aldehydes, volatile esters, fusel alcohols, furfural, volatile (expressed as acetic acid), and other aromatic compounds. The highest content of volatile compounds had distillate from the variety Morava (7745.15 mg per litre of 100% alcohol) and the lowest content had distillate from the variety Rea's Mammoth (5094.14 mg per litre of 100% alcohol) (Table 7).

Table 7. Chemical composition of final distillates (in mg/L of 100% alcohol)

Quince variety	Vranjska (SRB)	Leskovačka (SRB)	Morava (SRB)	Pazardžijska (BLG)	Hemus (BLG)	Asenica (BLG)	Portugal (POR)	Triumph (BLG)	Rea´s Mammoth (USA)
Ethanol (%vol)	40.46	40.89	39.90	40.70	39.90	39.71	40.39	40.33	40.15
Methanol	8411.77	7554.99	7321.54	7197.99	9074.08	10088	6592.58	6632.18	8059.19
Aldehydes	281.06	318.51	366.11	261.62	251.43	268.14	217.88	451.67	217.88
Ethyl acetate	696.1	443.25	1956.66	657.14	566.46	452.36	429.81	313.69	401.73
Furfural	24.23	16.50	8.38	11.28	14.77	22.68	9.17	13.54	22.53
Total acids (mg/L)	87.6	43.2	109.2	40.8	40.8	39.6	43.2	56.4	54.0
Volatile compounds	6019.39	5550.26	7745.15	7133.04	6492.66	5980.18	6801.86	5713.9	5094.14
n-propanol	318	387	482	636	460	426	354	389	352
i-propanol	0	0	0	0	0	0	0	0	0
n-butanol	6	20	12	8	6	5	7	5	5
i-butanol	740	653	879	919	773	648	908	564	547
i-amyl alcohol	3954	3712	4041	4640	4421	4158	4876	3977	3548
Total fusel alcohols	5018	4772	5414	6203	5660	5237	6145	4935	4452

Methanol is a naturally occurring compound in spirit drinks and is derived from pectic substances by hydrolysis. Its amount is higher in fruit than in grain spirits and can be used as a sign of spirit authenticity [20]. Small concentrations of methanol in fruit spirits are considered safe, while high concentrations have different negative effects on human health. In our study, the lowest methanol content had distillate from the variety Portugal (6,592.58 mg per litre of 100% alcohol), and the highest content had distillate from the variety Asenica (10,088 mg per litre of 100% vol. alcohol). The allowed concentrations of methanol in alcoholic drinks made from quince are up to 13,500 mg per litre of 100% alcohol [19]. Our results showed that methanol concentrations are in the safe-to-use range.

Aldehydes are a large group of compounds that are formed by the oxidation of primary alcohols. They give a specific aroma – fruity and floral, and although aldehydes are found in smaller concentrations than esters and alcohols, they are easily detected by smell receptors [21]. The most abundant aldehyde in fruit spirits is acetaldehyde, which makes up 90% of the carbonyl fraction in spirits. The final concentration of acetaldehyde in fermented beverages or raw distillates is highly correlated to the fruit used for fruit spirit, while it is not correlated with the type of yeast strain [22]. The lowest aldehyde content had distillates from varieties Portugal and Rea's Mammoth (217,88 mg per litre of 100% alcohol) and the highest amount was found in distillate from variety Triumph (451,67 mg per litre of 100% alcohol).

Another group of volatile compounds that determine the fruity character of the spirit are esters. Even small changes in esters can result in a noticeable effect on the final quality of the spirit. Some esters can show a negative contribution to the beverage sensory traits, e.g. ethyl acetate if present in higher concentrations [9].

Ethyl acetate gives a specific solvent-like aroma [23], and it is an indicator of fermentation purity (presence of acetic acid bacteria). In smaller quantities, it gives a pleasant smell to the spirit [24]. The lowest ethyl acetate content had distillate from the variety Triumph (313,69 mg per litre of 100% alcohol) and the highest ethyl acetate content was found in distillate from the variety Morava (1956,66 mg per litre of 100% alcohol). The final esters profile in fruit spirit depends on the conditions of fermentation (temperature, aeration and hydrostatic pressure), strain type and the material used for fermentation [23] and cutting the head fraction. Since in our study all samples were exposed to the same fermentation conditions, the same strain was used and the same amount of cut head fraction, the noticed differences are exclusively genotype-related.

Furfural is not present in the raw materials (fruit), but is exclusively formed during the distillation, at higher temperatures. It is a common compound in natural fruit spirits and an indicator of the natural origin of the spirit. It gives a specific bitter almonds smell [24]. Higher amounts of furfural indicate burning, therefore in „burned" distillates, furfural can be found in an amount of 30 or up to 120 mg per litre of 100% alcohol. Usually, it can be found in amounts below 10 mg per litre of 100% alcohol. Furfural range from 8,38 (Morava) to 24,23 (Vranjska) mg per litre of 100% alcohol indicated that no burning has occurred during distillation.

The distillate from the variety Pazardžijska had the highest amount of total fusel alcohols (6203 mg per litre of 100% alcohol), and distillate from the variety Rea's Mammoth had the lowest content of total fusel alcohols (4452 mg per litre of 100% alcohol) (Table 7). Fusel alcohols are one of the most important volatile chemicals in spirits, which can have a positive or negative contribution to the sensory traits of fruit spirits. In the appropriate concentrations, fusel alcohols improve the quality of the fruit spirits and provide specific aroma and flavour depending on the concentrations of individual fusel alcohols that are present [25]. Since the individual content of each fusel alcohol and their mutual relations depend on the setting of the alcoholic fermentation, yeast and the chemical character of the raw material, fusel alcohols are the parameters for determining the authenticity of fruit spirits [26].

The usual amount of fusel alcohol found in fruit spirits is between 1000 and 5000 mg per litre of 100% alcohol in different fruit spirits, including quince spirit [25]. By EU regulation, the number of volatile compounds in spirit drinks, including fusel alcohols, should be over 2000 mg/L [27]. On the other hand, too high fusel alcohol concentrations lead to a negative effect on the aroma and flavour and have intoxicating effects. The study of 290 different spirit samples in Europe showed that the mean amount of fusel alcohols is 4000 mg/litre, while concentrations above 10,000 mg/l are extremely rare and should be treated with precaution since there are indications that concentrations above 10,000 mg/l can have a toxic effect [28]. Our data showed that all analyzed fruit spirits had optimal fusel alcohol content (Table 7).

The most important fusel alcohol is iso-amyl alcohol, which gives a specific banana flavour and can implicate the character of fruit spirit [29]. Other abundant fusel alcohols are *i*-butanol, *n*-propanol, and *n*-butanol. *N*-propanol gives a mellow and refreshing taste [30]. Isoamyl alcohol had the largest share in total fusel alcohol content in analyzed spirits, followed by isobutanol, *n*-propanol and *n*-butanol.

The concentrations and ratio of abundance of fusel alcohols can implicate the sensory quality of the fruit spirit. This implicates that fruit spirits made from the Portugal variety will have good sensory properties, while Rea´s Mammoth will have a little weaker sensory evaluation grade. Still, differences between cultivars in regard to i-amyl alcohol amount are too small to expect significant difference among spirits from different cultivars.

While optimal fusel alcohol does not affect the intoxicating degree (ID) of fruit spirit, the ratio between isoamyl alcohols to isobutanol is highly correlated to ID [31]. The ratio of these two fusel alcohols depends on amino acids and ammonium content. This ratio is the highest in spirits distilled from Triumph (7,05) and Rea Mammoth (6,48), while Morava and Pazardžijska had the lowest IA/IB ratio (4,95 and 5,05 respectively). On the other hand, the amount of *n*-propanol, *i*-amyl alcohol and *i*-butanol was the highest in Pazardžijska.

Conclusion

The weight and dimensions of the fruit varied considerably between varieties. Most varieties had a round fruit shape, which is the most suitable for processing. The varieties Vranjska and Portugal had the highest fruit firmness, and Pazadržijska and Triumph had the lowest. In terms of the chemical composition of the fruit, the varieties Morava, Leskovačka and Asenica stood out. The sensory properties were consistent with the chemical composition of the fruit. In general, the best results regarding fruit quality were shown by the varieties Morava, Leskovačka and Asenica.

The highest alcohol yield had spirits made from varieties Leskovačka and Asenica, while the lowest alcohol yield had spirits made from the variety Rea's Mammoth. As for chemical composition, all compounds, including methanol content, were in accordance with the legal regulations.

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Izvod

UTICAJ SORTE DUNJE NA SADRŽAJ ALKOHOLA I KVALITET DUNJEVAČE

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Neke od specifičnih karakteristika dunje, kao što je visok sadržaj pektinskih supstanci i relativno nizak sadržaj fermentabilnih šećera, dovode do određenih izazova u alkoholnoj fermentaciji. Cilj ovog istraživanja bio je evaluacija uticaja sorte dunje na dinamiku fermentacije, prinos alkohola i hemijski sastav proizvedenih pića. U ovim istraživanjima korišćeno je devet sorti dunje iz kolekcionog zasada na Oglednom polju “Radmilovac” Poljoprivrednog fakulteta Univerziteta u Beogradu: Vranjska (SRB), Leskovačka (SRB), Morava (SRB), Pazardžijska (BLG), Hemus (BLG), Asenica (BLG), Portugalska (POR), Trijumf (BLG) Mamutova dunja (SAD). Istraživanja su obavljena u toku 2018. godine. Rastvorljive suve materije u plodovima dunje su varirale od 12.90% (Pazardžijska) do 16.80% (Morava). Ukupni šećeri i ukupne kiseline su bile u opsegu od 6.74 % i 0.53% w/w (Pazardžijska) do 9.76 % and 1.27% w/w (Morava). Najviši sadržaj alkohola su imala pića napravljena od sorti Leskovačka i Asenica (9.88 litara 40% alkohola na 100 kg ploda), dok je najniži sadržaj alkohola bio prisutan u piću napravljenom od sorte Mamutova dunja (7.20 litara 40% alkohola na 100 kg ploda). Svi uzorci pića su imali zakonski dozvoljen sadržaj metanola (do 1350 g/hl na 100 % alkohola) i parametara kvaliteta pića.

Ključne reči: rakija od dunje, kvalitet pića, sadržaj alkohola, metanol, isparljiva jedinjenja