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REINVENTING THE TRADITIONAL PRODUCTS - THE CASE OF BLACKBERRY WINE

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review paper

Summary

Blackberry wine is traditionally produced in the continental parts of Croatia and consumed in moderate quantities as a dessert wine. It is often used as a popular remedy for anaemia and iron deficiency, as well as for alleviating sleep disorders, because of its mineral composition comprising among other elements, iron and magnesium. Besides minerals, blackberry wine is a good natural source of strong antioxidants, such as phenolic acids, anthocyanins, flavonols, catechins and other flavonoids. For a long time, fruit wines in Croatia were mainly produced by traditional methods in small scale. Therefore, the wines were of inconsistent characteristics and often lower quality. Small and medium scale producers are now implementing the more appropriate modern production technologies to achieve good fermentation control and produce high-quality blackberry wine. Consumers are looking for a fruit wine with traditional, geographically unique characteristics, as well as appropriate enological properties, sensory attributes and high added value (*e.g.* wine rich in bioactive compounds). This is in accordance with the trends in the food industry and food markets (functional, organic) that are geared towards the development of new products with the high added value associated with health or well-being of environment and society. This work aims at reinventing the traditional product blackberry wine, through the prism of claims and requirements for functional and organic foods.

Keywords: blackberry wine, functional products, organic products, winemaking practices

Introduction

Among the traditional alcoholic beverages of Croatia, blackberry wine has been valued and cherished as a natural remedy for iron deficiency (anaemia). Furthermore, it is generally believed that moderate drinking of blackberry wine can help treat exhaustion and loss of appetite, regulate the digestion and blood pressure, increase the blood cell counts and improve the overall health status. Blackberry wine is obtained by the alcoholic fermentation of fresh blackberry juice or blackberry must. Alcoholic fermentation, performed by yeast, is a complex biochemical process of sugar decomposition with the formation of ethanol and carbon dioxide as the main products and several secondary products essential to the overall quality of blackberry wine. Blackberry wine proved to be an excellent natural source of dietary fibres, minerals, and many bioactive phytochemicals with strong antioxidant potential, such as flavonols, anthocyanins, phenolic acids, vitamins, and others (Amidžić Klarić et al., 2011a). Having all this in mind, it is understandable why the homemade production of blackberry wine in Croatia has been continually flourishing. However, the scale-up of blackberry wine production has been relatively slow compared to grape wines. The vast majority of blackberry wine producers in Croatia are small and medium-scale family businesses, often incorporating both blackberry cultivation and blackberry wine production. The trends in the food industry and the recommendations of nutritionists are geared towards the development of new functional products, which offer benefits beyond their nutritional value by exerting positive effects on human health. In that sense, blackberry wine can be considered as a functional product (Dey and Sireswar, 2019). Valls et al. (2013) stated that functional foods and nutraceuticals are one of the top trends in the food industry. The high portion of blackberry wine production in Croatia is based on organically cultivated blackberry. Besides functional foods, organic foods are another segment of the European and global food market that has seen a constant growth within the last couple of decades. Both organic and functional food markets aim at providing consumers with high-quality products with added value. The added value of functional foods is associated with health, while the added value of organic products, besides health, extends to the well-being of the environment and the society in general (Khal et al., 2012; Popa et al., 2018). In this way, the traditional products, such as blackberry wine, now being labelled as functional or organic, are being reinvented in order to gain full market acceptance.

This work aims to give a new insight into the traditional product, *i.e.* blackberry wine, through the prism of claims and requirements for functional and organic foods.

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From Blackberries to Blackberry Wine - Obtaining a High-Quality Product with Added Value

The essential step in high-quality blackberry wine production is the selection of berries. The blackberry fruit is a delicate and aromatic aggregate fruit, which has a refreshing acidic-sweet taste and high nutritional value. The nutritional value of blackberry and fruit products derived from its processing are given in Table 1. Fresh, high-quality blackberries contain high amounts of nutrients (sugar, organic acids and dietary fibres) and bioactive phytochemicals that play an essential role in health promotion and disease prevention, such as already mentioned minerals, flavonols, anthocyanins, phenolic acids, vitamins and others (Lenter, 2000; Amidžić Klarić, 2011c; Schulz et al., 2019). Some of them survive the winemaking process and transfer to blackberry wine unchanged, while others are subjected to changes during and after alcohol fermentation as well as maturation (Amidžić Klarić, 2011). The overall chemical composition of blackberry wine comprises mainly water and ethanol, followed by glycerol, organic acids (malic acid as the major organic acid present in blackberry), residual sugars, aroma compounds (esters, higher alcohols, acetates, aldehydes, ketones, lactones, terpenes and phenols), as well as minerals and phenolic compounds. The two latter ones being the most important when discussing the blackberry wines as functional foods.

Table 1. The nutritional value of blackberry and fruit products derived from its processing is expressed in 100 g of product (Brodarec, 1976)

Ingredient		Fresh blackberry	Frozen blackberry	Blackberry juice
Water (g)		82 – 86	74.3 – 82	85.8
Proteins (g)		0.7 – 1.3	0.8 – 1.0	0.8
Fats (g)		0.4 – 0.9	0.3 – 0.5	0.8
Carbohydrates (g)	Total	11.5 – 12.9	15.7 – 24.4	12.1
	Mono- and disaccharides	6.4	7.8	
	Dietary fibres	4.1 – 7.3	1.8 – 7.2	2.7
Total acidity (expressed as citric acid) (g)		1.5		
pH value		3.2		
Ash (g)		0.5	0.5	0.5
Vitamins				
Carotenes		100 - 230 IU 96 μg	140 IU 66 μg	150 IU
Retinol (μg)		16	11	
α-tocopherol (mg)		0.35 – 0.6		
L-ascorbic acid (mg)		20 – 21	8	5 – 10
Thiamine (mg)		0.03	0.02	0.02 – 0.03
Riboflavin (mg)		0.04	0.1	0.03 – 0.05
Niacin (mg)		0.4	0.6	1.2
Pyridoxine (mg)		0.05		0.06
Nicotinic acid (mg)		0.4		0.3
Pantothenic acid (mg)		0.25		
Biotin (μg)		0.4		
Mineral composition				
K (mg)		170 – 210	105	160 – 170
Ca (mg)		32 – 63	17	20 – 25
Na (mg)		1 – 4	1	1
Mg (mg)		23 – 30	12	22
Fe (mg)		0.55 – 1	0.6	0.4 – 0.9
Cu (mg)		0.12		
Zn (mg)		0.27		0.25
P (mg)		19 – 25	17	17 – 30
Cl (mg)		22		
S (mg)		17		
Energy value		29 – 58 kcal 121 – 253 kJ	72 – 96 kcal 300 – 400 kJ	54 kcal

Table 2 gives a list of some of the phenolic compounds and minerals determined in Croatian blackberry wines. The epidemiological studies have proved that phenolic compounds prevent diseases such as cancer, diabetes, osteoporosis, cardiovascular and neurodegenerative diseases (Arts and Hollman, 2005; Graf et al., 2005). Even though there is a lack of research on the health benefits of fruit wines, it is expected that the presence of ethanol in blackberry wine enhances the bioavailability of phenolic compounds, which can be supported by the results reported by some authors that indicate higher health benefits of grape wines than the isolated phenolic extracts alone or alcohol-free wine (Gambelli and Santorini, 2004; Cliff et al., 2007). Small amounts of minerals are required for various metabolic processes essential for the functioning of the human body (Gharibzahedi and Jafari, 2017). According to Caillot et al. (2018), some polysaccharide fractions isolated from blackberry wine markedly reduced nitric oxide and pro-inflammatory cytokine production (TNF-α and IL-1β) in lipopolysaccharide-treated cells.

Table 2. Some of the phenolic compounds and minerals determined in Croatian blackberry wines (Amidžić Klarić et al., 2011[a,b]; Amidžić Klarić et al., 2016[c]; Amidžić Klarić et al., 2017[d])

	Blackberry wine (No. of samples)[Ref.]
Total phenolics*	733 – 2698 (17)[a]
Total anthocyanins**	1.3 – 125.3 (17)[a]
Individual phenolic compounds	
Flavonol	
Quercetin	0.8 – 21.7 (15)[d]
Anthocyanins	
Cyanidin (as aglycon)	<LOD – 3.2 (15)[d]
Pelargonidin (as aglycon)	<LOD – 1.46 (15)[d]
Phenolic acids	
Gallic acid	28.1– 122.4 (17)[a]
Caffeic acid	2.0 – 4.8 (17)[a]
Chlorogenic acid	1.0 – 3.9 (17)[a]
p-Coumaric acid	01.0 – 4.4 (17)[a]
Metals	
K	564 – 2014 (32)[b,c]
Na	12 – 213 (32)[b,c]
Ca	86 – 457 (32)[b,c]
Mg	706 – 381 (32)[b,c]
Fe	0.082 – 8.4 (32)[b,c]
Cu	0.06 – 0.77 (32)[b,c]
Mn	0.7 – 11.5 (32)[b,c]
Zn	0.25 – 6.65 (32)[b,c]

Legend: all values are expressed in mg/L; *values are expressed as gallic acid equivalents; **values are expressed as malvidin-3-glucoside equivalents; LOD - Limit of Detection.

Blackberry wine as a functional product

Can blackberry wine be considered a functional product? To answer this question, it is necessary to have a distinctive, unmistakable definition of functional foods. Doyon and Labercque (2008) concluded that despite the large body of literature dealing with legislative, technological perspectives and market potential of functional foods, the commonly accepted definition of functional foods is still lacking. Therefore, they generated the following definition based on the extensive literature review and the use of Delphi technique with a group of experts in the field: "*A functional food is, or appears similar to, a conventional food. It is part of a standard diet and is consumed regularly, in normal quantities. It has proven health benefits that reduce the risk of specific chronic diseases or beneficially affect target functions beyond its basic nutritional functions*".

Blackberry wine, as a traditional product, is, by all means, conventional food product. It is not part of the standard diet, as most of the alcoholic beverages. However, in Croatia, it is often regularly consumed in small amounts by people with iron deficiency. Therefore, it fits a normal consumption pattern in a specific geographic/cultural context (Doyon and Labercque, 2008). Even though it is generally believed that blackberry wine has many health benefits, the research to date has tended to focus on

the pharmacological activity of blackberries rather than blackberry wine, so the scientific literature on health benefits of blackberry wine (or other fruit wines for that matter) beyond its nutritional functions is scarce. Functional food is still not regulated in Europe, so the formal labelling does not exist. EC-regulation 1924/2006 regulates the claims (for consumers' information) related to the positive health effects of foods. The scientific evidence for claimed health benefits should be provided (Kahl et al., 2012). Mudnić et al. (2012) made a comparison of four blackberry wines with two red and two white grape wines based on their *in vitro* antioxidant and vasodilatory effects. The antioxidant capacity of the examined blackberry wines proved to be stronger than that of the examined grape wines, despite their lower total phenolic content. The blackberry wines proved to be less potent vasodilators than their grape wine counterparts. The overall results indicate the biological potential of blackberry wines and call for further research. Ljevar et al. (2016) studied the phenolic profile of different Croatian fruit wines, including blackberry wine, and evaluated their antioxidant and biological potential. Blackberry wines contained a high amount of total phenolics with distinctive phenolic composition. Along with other examined fruit wines, they inhibited the growth of human cancer cells *in vitro* in a dose-dependent manner, with higher susceptibility in HeLa and MCF-7 cells than CaCo-2 cells. The mineral composition of 17 commercially available Croatian blackberry wines was investigated by Amidžić Klarić et al. (2011b). The results showed that tested wines could be considered as an additional source of magnesium, manganese and potassium. All being said, it can be concluded that blackberry wine could be considered as a functional food. However, the caution must be exercised when a formally labelling product as functional, since the regulation to date does not exist and proper scientific validation of health benefits must be provided for each product.

Blackberry wine as an organic product

The new lifestyle trend known as "green consumerism", with people demanding more foods that are organic and with reduced levels of chemical preservatives for food production and preservation (Leite et al., 2006), has led to a re-discovery of traditional food products (Settanni et al., 2012). At the same time, a traditional product associated with a given geographical area is positively perceived (Francesca et al., 2016). Consumers' demands for organic food is constantly increasing, since it is perceived as more valuable than conventional food, concerning its essential nutritional, sensory and safety properties. Furthermore, it is believed to be more environmentally friendly and more respectful to the welfare of the animals (Suciu et al., 2019). EU market analyses show that the food produced by organic standards is currently mostly lacking. However, the quality-quantity ratio of Croatian domestic organic products is still insufficient, and they do not match the price of products that mostly come from imports. This can also be applied to blackberry wines made from organically grown fruit.
Until recently the cultivation of blackberry in Croatia was reduced only to the exploitation of wild species. However, the cultivated farming of blackberry has started in the continental part of the country, mostly on small family plantations using traditional cultivation techniques and manual harvesting. Thornless Logan, Thornfree, Black Satin and Tayberry are the most commonly cultivated cultivars of blackberry in Croatia, with significant quantities of fresh fruit directly processed into fruit products - jam, juice or wine (Voća et al., 2008). A large portion of the cultivated blackberry farming is based on organic principles, and consequently so is the blackberry wine production. Organic food production is a unique system of sustainable management in agriculture, food industry and forestry, which includes the cultivation of plants and animals, food, raw materials and natural fibres, and the processing of primary products. The production of organic foods in the European Union has been regulated by Commission Regulations (EC) 834/2007 and 889/2008 and Commission Implementing Regulation (EU) 203/2012. Although demands related to organic production vary, some rules are applied generally, *e.g.* the use of herbicides, chemosynthetic insecticides and organic fungicides is uniformly prohibited (Velić, 2014). The purpose of such production is to protect the health and life of people and the environment. Phytopharmaceuticals (*i.e.* pesticides, herbicides, fungicides) and artificial fertilisers are replaced by natural, ecological means, thus preserving soil fertility, purity of water and air. The quality of organic products is controlled, which is of great interest to consumers. Organic food production has many advantages (increasing the overall quality of food products, environment protection, rural development), and such products can achieve higher market prices and are more profitable than those produced conventionally. In the organic food processing industry, which also includes blackberry wine production, there is a need to develop and monitor all relevant production phases trying to preserve the nutritional and sensory properties of the raw material. In this sense, the

minimal processing of the raw material is required. It is also essential to establish a comprehensive process with an emphasis on food safety and quality standards, packaging handling, traceability, control and certification systems.

Conventional and organic cultivation practices differ significantly. However, research on the impact of the cultivation method, *i.e.* organic farming on nutritional quality and health effects of the organic foods often give inconsistent results (Vinković Vrček et al., 2011). Lower levels of known toxicants (nitrates; phytopharmaceuticals, namely pesticides) have been reported in organic products, but natural toxic contaminants (*e.g.* mycotoxins) should be more closely monitored in organic production (Pussemier et al., 2006). When comparing the organic and conventional food products based on nutrients and health-related compounds, the already mentioned inconsistency of results is present. Vinković Vrček et al. (2011) evaluated the mineral and polyphenol content and antioxidant capacity of wines produced from conventionally and organically grown grapes and concluded that the values of antioxidant activity were higher in organic wines. Amidžić Klarić et al. (2017) evaluated the quercetin content, colour and selected physicochemical quality parameters of Croatian blackberry wines produced from organically and conventionally grown blackberries. Quercetin content of organic wine samples group was slightly higher than that of conventional wine samples group. Vitali Čepo et al. (2018) compared the Croatian organic and conventional grape wines based on the levels of pesticide residues and mycotoxin Ochratoxin A. The results showed that organic wines contained significantly lower levels of pesticides and that ochratoxin A positive wines mostly belong to the conventional group. The health effects of functional foods are based on the presence and concentration of specific bioactive compounds and thus, measurable and comparable to conventional foods.

On the other hand, organic food has no placebo for comparison, and it is difficult to support the health-related claims of organic foods. This, however, does not stop the consumers from buying organic food, since they perceive it as more natural and better for their health, the environment and society in general (Kahl et al., 2012). It is, therefore, expected that the Croatian organic blackberry wine would also find its way to the global organic foods market.

Traditional Production ("homemade") *vs* Modern Winemaking Practices

Blackberry wine, and all other non-grape wines for that matter, in Croatia and Europe, is covered by the regulations on fruit wines that define the fruit wines must be obtained by the fermentation of the juices of fruits other than grape (Ordinance on fruit wines, OG 73/06, 24/11, 120/12, 59/13). Furthermore, the regulations define the primary classification of fruit wines to still and sparkling, and the alcoholic strength permitted by different national regulations between 1.2% and 14% by volume (Kosseva et al., 2017).

Blackberry wine quality concept is taking into consideration both physico-chemical and sensory characteristics of wine, which are influenced by various factors: soil, climate, mode of blackberry cultivation and applied cultivation practices, selection of cultivar, agro-technical variables such as physiological state of the raw material at harvest, the proportion of relevant constituents (sugars, organic acids, bioactive compounds, aroma, colour etc.), implementation of maceration, enzymatic processing, selection of yeast and optimisation of fermentation conditions, fermentation equipment etc. (Velić et al., 2013; Petravić Tominac et al., 2013; Velić et al., 2018a).

As already mentioned, the scale-up of fruit wine production, including blackberry wine, has been slow and the majority of producers are small and medium-scale businesses. This could probably be the reason why consumers often associate fruit wines with "homemade" products, which implies lower quality. Setting the consistent standards of quality for fruit wines, as well as marketing initiatives, are needed to alter this perception (Velić et al., 2018b). Traditional homemade blackberry wine is a very heterogeneous group of products from the perspective of its oenological (and consequently functional) properties. The quality of the product depends on the specific blackberry wine recipe, used equipment that is often very simple (plastic vessels for maceration, glass demijohns or plastic barrels for fermentation) and winemaking practices that seldom include the use of maceration enzymes and sulphur. Furthermore, the use of selected wine yeasts is often omitted, and the fermentation temperature is not controlled. All this leads to inconsistent product quality and often also to wine spoilage.

Modern winemaking practices implemented in blackberry wine production tend to change this inconsistency and yield a product of consistent (high) quality. Apart from a careful selection of raw material, modern practices include the use of selected wine yeasts and modern fermentation equipment made of food-grade stainless steel (AISI 304), as well as a double-jacket fermenter for cooling (temperature control) and air-locks. The general scheme of modern blackberry wine production is given in Fig. 1.

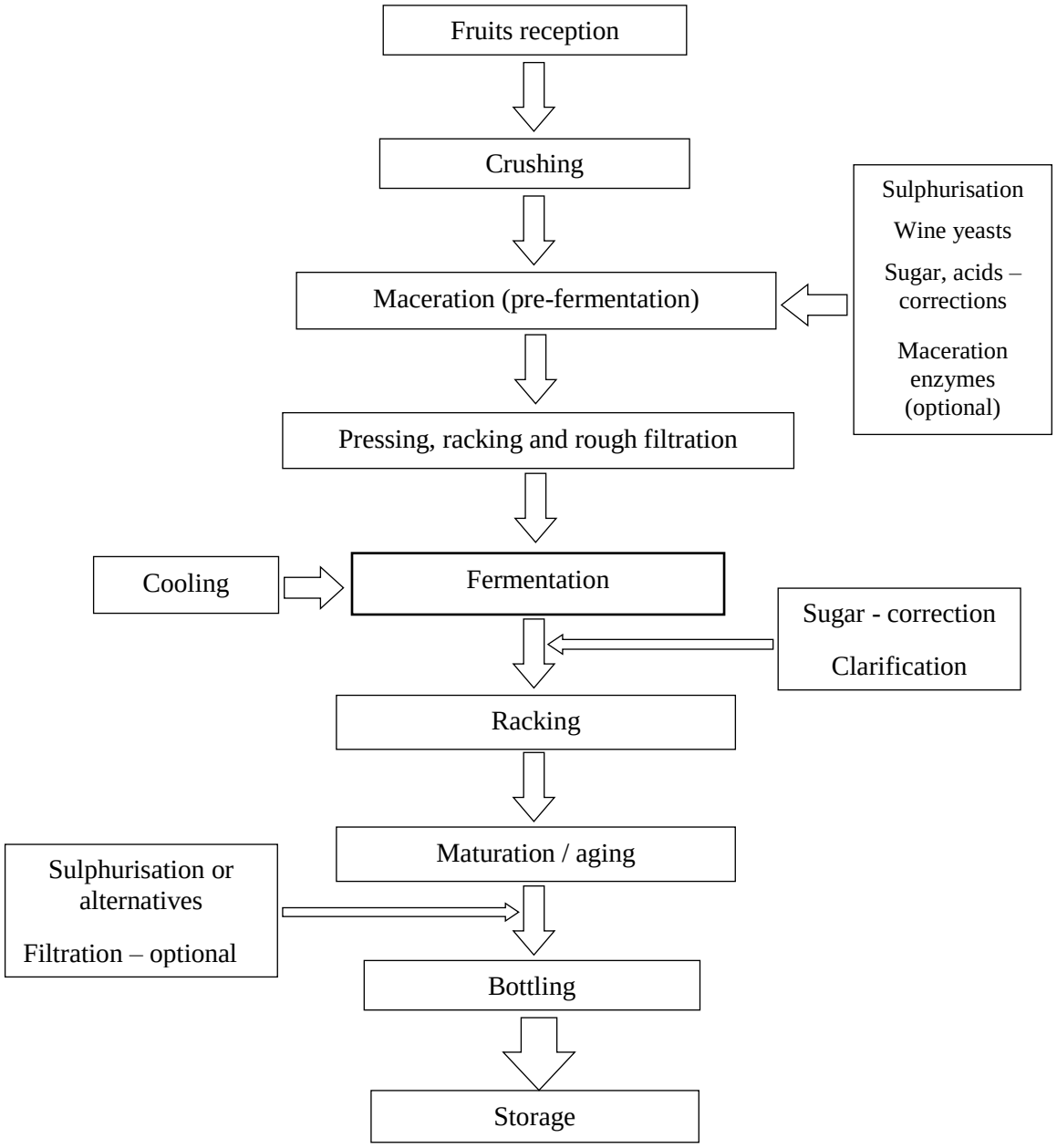

Fig. 1. General scheme of modern blackberry wine production (Velić et al., 2018b)

One of the most significant improvements in wine production in general, but also in blackberry wine production, is better fermentation control using selected yeast strains. Oenological traits of wine yeasts have been divided into two groups, *i.e.* technological and qualitative. Both groups of traits have to be considered when selecting wine yeasts (Rainieri and Pretorius, 2000). Technological traits influence the fermentation efficiency, while qualitative traits determine the chemical composition and sensorial characteristics of wines (Petravić Tominac et al., 2013; Velić at al., 2018a). Tomić et al. (2018) studied the influence of pectolytic enzymes and selected yeast strains on the chemical composition of blackberry wines of Thornfree cultivar and concluded that both enzymes and yeast significantly affected the chemical composition and quality of blackberry wines, especially the concentration of individual anthocyanins in the analysed wines.

EC 889/08 and the Ordinance on wine regulate the production of organic grape wine in conjunction with the detailed provisions of EC 203/2012, Annex VIII.a. These regulations are also applied to organic fruit wine production. It provides the list of allowed oenological additives, as well as allowed practices. According to these regulations, enological additives for organic wine production include:

- *Organic Wine Yeast* (*Saccharomyces cerevisiae*) – 20 - 30 g per 100 kg mass at the initial stage of maceration. It is necessary to provide a GMO-free declaration for yeasts on the prescribed form by EC 889/08, Annex XII.
- *Yeast nutrients* (optional) that can be added during the rehydration of yeast or in case of a stuck fermentation.
- *Potassium metabisulfite*, $K_2S_2O_5$, (5 - 7 g/hL or 30 to 50% lower than the amount recommended for the conventional wine production). K-metabisulfite degrades, among others, to sulphur dioxide (SO_2), which protects wine on several levels (essential free sulphur dioxide, SO_2). The use of permitted oenological additive (E224) is carried out by the recommendations for organic food production according to EC 889/08, Annex VIII and the Ordinance on wine related to the detailed provisions of EC 203/2012 Ecological Wine Annex VIIIa. The total free SO_2 concentration should not exceed the prescribed concentration of 50 mg/L.
- *Maceration enzymes* (optional) can be added to increase the yield, colour and stability (see Fig. 1). The so-called "maceration enzymes" include pectinases and small amounts of cellulase and hemicellulase. They provide better extraction of compounds which contribute towards aroma, colour and health benefits of wine from the fruit during maceration.
- *Brown organic sugar, certified* is added during maceration in order to adjust the sugar content of must, as well as after the fermentation is completed (see Fig. 1). Blackberry fruit is acidic and much lower in sugar content than grapes, so the sugar content has to be adjusted to make it suitable for winemaking. Unlike grape wines production, fruit wines production allows the addition of sugar, fruit juice or concentrated fruit juice in wine, as long as the content of the actual alcohol at the time of delivery to the consumer does not exceed 13% vol (Ordinance on fruit wines, OG No 73/06, 24/11, 120/12, 59/13).
- *Wine clarification agents*, such as pentagel (bentonite) or active sodium bentonite, may be added to the must (better phase separation) or wine before racking (see Fig. 1).
- *Ascorbic acid (vitamin C), certified GMO free* is added to the finished wine as a preservative and antioxidant.

Since blackberry wine has a high amount of residual sugar (initial sugar addition or addition after fermentation) and filtration is mostly omitted to prevent significant loss of colour (residual yeast cells), the main problem associated with blackberry wine production is possible refermentation of wine. This is especially the case with organic blackberry wines because the addition of conventional wine preservatives and stabilisers is not permitted (Velić, 2014).

Other problems that can lead to blackberry wine quality deterioration include inadequate storage, exposure to temperature oscillations (exposure to temperatures above ambient), mechanical packaging damage, high concentration of nitrogen compounds, low concentration of free SO_2, etc. It is recommended that organic wines be appropriately stored in a cool place (Velić, 2014).

Some of the basic physico-chemical properties of blackberry wine which determine the overall wine quality are the contents of alcohol, residual sugar, total and volatile acids, free and bound SO_2, phenolic and aroma compounds, as well as wine colour. Table 3 gives an overview of the average values of some (basic) physico-chemical properties of Croatian organic fruit wines over the ten years (2008 – 2017). The samples were obtained from small and medium-scale organic blackberry wine producers from Slavonia and Baranja region and analysed at the Faculty of Food Technology Osijek. Part of the results presented in Table 3 includes those obtained by the VIP project: "Development and Standardisation of Organic Blackberry Wine Production", funded by the Croatian Ministry of Agriculture, 2012 – 2014.

Table 3. Average values of basic physico-chemical parameters of organic blackberry wines for the period 2008 – 2017

Physico-chemical parameter	Value (range)	Unit
Total alcohol	16.1 – 19.2	% vol.
Real alcohol	10.8 – 13.0	% vol.
Reducing sugars	67.8 – 98.5	g/L
Total sugar	71.3 – 98.5	g/L
Total extract	107.4 – 148.3	g/L
Extract (total sugar excluded)	35.3 – 49.7	g/L
Ash	2.6 – 3.9	g/L
pH	3.27 – 3.68	-
Total acidity (as malic acid)	10.2 – 11.9	g/L
Volatile acidity (as acetic acid)	0.4 – 0.7	g/L
Free SO_2	5 – 28	g/L
Total SO_2	49 – 125	g/L

Conclusion

In the light of new consumers' demands, traditional food products, such as blackberry wine are being rediscovered and reinvented to reach their full market potential. In that sense, informal labelling of blackberry wine as a functional product is part of the reinvention strategy. Furthermore, organic blackberry wines are even more valued, as they reflect the need to be in harmony with the environment and society in general. To obtain the high-quality blackberry wine that can be adequately marketed and positively perceived by the consumers, the transition from homemade products of inconsistent quality to consistently high-quality products had to be done. The process scale-up and the implementation of modern winemaking practice already led to the standardisation of blackberry wine production in Croatia. Further work is needed in the field of health studies that will test the positive health claims generally believed and associated with this traditional product in Croatia, thus making blackberry wine more recognisable at the global functional and organic food market.

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