

# Native cultivars of sour and sweet cherries in Croatia: main characteristics and potential of production in marginal areas

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## Abstract

The production of sour and sweet cherries is increasing thanks to the recognition of the nutritional and commercial value these fruit species have. Sour cherry has high levels of antioxidants and bioactive components, and it is technologically suitable for numerous ways of processing. There are plenty of novel food products that may be made from sour cherry fruits. Sweet cherry is, behind its nutritional value, recognized as a high-income crop mainly used for consuming in fresh condition. Among plenty of known cultivars spread internationally over the majority of production areas, there is also growing interest in local cultivars as a part of new and unique offers especially demanded by some categories of consumers. These cultivars are not spread widely but may be of interest for producers that are searching for a specific market niche, as well as consumers demanding something unique. We give a review of native cultivars of sour and sweet cherries grown in Croatia. Among sour cherries, the most important is 'Maraska' and 'Oblačinska', the first one by its unique aromas, high content of TSS, and adaptability to grow in marginal growing areas, while the other one by its high yield that does not have negative influence on the quality of fruits for juice and jam production and other processing purposes. These cultivars grow as populations with a high amount of accumulated variability and may be a source for clonal selection. We also give a review of internationally less known local cultivars of sweet cherries grown in Croatia ('Tugarka', 'Creska', 'Okička', 'Gomilička', etc.) grown within certain areas of production, providing their pomological and technological description, pointing out their adaptability to certain marginal producing conditions and other traits that may attract the interest of growers internationally.

**Keywords:** cherries, fruit characteristics, aroma, TSS

## INTRODUCTION

Sour cherries (*P. cerasus* L.) and sweet cherries (*P. avium* L.) are known as appreciated fruit in Europe since the Roman Age. Trading connections developed by Romans and ethnic migrations during the Roman age made conditions for spreading of these fruit species from the place of their domestication that probably occurred at the territory of Greece in the 6<sup>th</sup> and 7<sup>th</sup> century BC (Iezzoni et al., 1991) to all over southern and central Europe. We could call it the first wave of cherry spreading. However, the gene center of origin of sour and sweet cherry is at the Caucasus Mountains (Hummer and Janick, 2009) where the highest level of variability is observed. If focusing on the Balkan Peninsula we could assume that some of the sweet cherry cultivars spread to the west in what we could call the second wave of the spreading of cultivars that occurred during the Ottoman era. In that period some of the cultivars spread to the western part of the Ottoman Empire over the territory that subsequently became Yugoslavia, and further to the west, behind the borders of the Habsburg Monarchy and Italian states, between the 17<sup>th</sup> and 19<sup>th</sup> centuries. This assumption is corroborated by the analysis of some of the native cultivars from this geographical region, names of the cultivars, and comparative analyses of ancient and recent literature about sweet cherries.

Sour and sweet cherries have also unique nutritional value. Their fruits are a rich



natural source of antioxidants (especially sour cherry) phenolic compounds, vitamins, minerals, carotenoids, and indolamines (Serradilla et al., 2017) that is the basis for their usage in the processing and invention of novel nutritional products.

Growing sour cherries in climatologically marginal production areas, as grown in Croatia, may be considered as a possible model for other countries in the Mediterranean basin with similar climate and soil conditions. Today, rapid ecological changes that influence horticultural production in many vulnerable agricultural ecosystems act as forces that stipulate the need for horticultural crops and cultivars that have a genetic predisposition for adaptation to fast ecological changes. Some cultivars of sour cherry, like 'Maraska' are adapted to marginal production areas: skeletal soils with more than 35% of rock fragments and limestone concretions, as common in many parts of the Mediterranean region. Sour cherry is, in the same way, tolerant to temperatures higher than 35°C during the summer months, but also tolerant to temperatures that may fall slightly below 0°C for some hours in just a few spring days during the flowering time. This is the temperature range quite common in the Mediterranean part of Croatia.

## **MATERIALS AND METHODS**

The sources of information are the existing literature on cherry cultivars and their overviews, their evaluation, and genetic analyses. The sources include ancient and recent own literature and literature by other authors which are not easily accessible because they are either in the Croatian language or were presented at national conferences with only limited appeal within national borders. This, of course, by no means reduces the specific importance of these reports. We are attempting to integrate all the relevant data on native (autochthonous or local) cultivars, to compare the data of ancient sources with the recent data. The final objective is to put into the context all facts about sweet and sour cherry, intending to provide an all-inclusive picture of these cultivars.

## **RESULTS AND DISCUSSION**

### **Sour cherry**

The attention regarding the most important sour cherry varieties in Croatia will be focused on two native cultivars, both of them genetically heterogenic populations, 'Maraska' and 'Oblačinska' sour cherries, widely grown in some parts of the country. 'Oblačinska' is grown in the northern, Pannonian part, and 'Maraska' in the southern, Mediterranean part of Croatia (the North and Middle Dalmatia). There are more than 500 cultivars of sour cherry grown in the world (Milatović and Nikolić, 2011), but the most important cultivars in Croatia, behind 'Maraska' and 'Oblačinska' are 'Rexelle', 'HeimansKonservenweichsell', 'Kelleris 14', 'Kelleris 16', 'Meteor korai' 'Double Gorse Kirk', etc. The production of 'Maraska' was growing until 1974, but it has been decreasing since then (Medin, 1997). During the last 20 years, the production is even more decreasing comparing to the 1970s and 1980s, especially for 'Oblačinska', as this cultivar is not suitable for mechanical harvesting. During the 1970s and 1980s, a buying off from small farm producers was regularly organized, and cherry was exported to the countries of western Europe. Nowadays the input price of labor makes it uncompetitive comparing to the countries with lower labor costs.

### **1. The most important cultivars in Croatia and their genetic identity.**

Genetic profiles of 'Maraska' and 'Oblačinska', the most important two cultivars of sour cherries grown in Croatia, as genotyped by SSR molecular markers are quite similar. They differ at only one SSR locus (out of seven), and the difference is only in one allele (marker) out of four that are existing in tetraploid heterozygous sour cherry (Puškar, 2005; Puškar et al., 2005). However, the genotyping in only seven SSR markers is not precise enough for a conclusion about the genetic distance and synonymy of these two cultivars. On the other side, we still do not have enough information to conclude these two cultivars are possibly different clones of only one cultivar, or they should still be considered as two completely different cultivars, as of now. Considering pomological and morphological differences between two

cultivars, and different chemical quality of their fruits which are known in the practice, and following the conclusion of Viljevac et al. (2009), we should consider and discuss both of them as unique cultivar. On the other hand, we should emphasize that both cultivars (and their clones) need to be analyzed using a significantly higher number of microsatellite loci, at least 16 SSRs recommended by Clarke and Tobutt (2009) as a core set of SSR markers for cherry identification.

#### 'Maraska' sour cherry.

'Maraska' ('Marasca') is probably the most famous sour cherry variety cultivated in Croatia. The production of 'Maraska' is mainly concentrated in middle and northern Dalmatia, in the hinterland of the towns of Zadar and Šibenik, and at the Adriatic island of Brač (Medin, 1997). The fruits and juice of 'Marasca' are the raw material for the most famous delicacy, liqueur Maraschino, known since the XVI<sup>th</sup> century and produced in Zadar until now. The different range of products is also produced from 'Maraska' sour cherry, like non-alcoholic beverages, marmalades, canned and bottled fruits (compotes), but also some novel products like spray-dried cherry powder or freeze-dried cherry fruits that might be utilized in confectionery and food industry for the development of functional food products (Pedisić et al., 2010; Garofulić et al., 2016), thanks to their suitability for processing and high content of bioactive compounds (Pedisić et al., 2007).

According to Medin (1968, 1989, 1997), there is high morphological variability of 'Maraska' expressed in the type of growth (*pendula* and *recta*), the shape of the leaf blade, and the length of the fruit stalk. There is also variability among the shape of fruit in further two types (*poljička* and *duguljasta*). *Poljička* has several disadvantages comparing to *duguljasta*: its fruit is round, but smaller in fruit size and with lower TSS contents. Therefore, it is not recommended for further propagation. The type *poljička* has a higher yield, it is more aromatic and has higher sugar contents, especially in shallow and more skeletal soils where it expresses optimal quality. Regarding the *recta* or *pendula* type of growth, both alternatives are recommended, although the production and distribution of propagating material should be separated for the two types. Higher quality of both types, in terms of higher TSS values and aroma content, despite lower yields, are obtainable in shallow skeletal soils. Although generally self-fertile cultivar, there are also detected self-incompatible genotypes (Medin, 1989). It emphasizes the need for clonal selection within the heterogeneous population, intending to eliminate self-incompatible genotypes. Detection of *Prunus necrotic ringspot ilarvirus* (PNRSV) in 48.3% of observed trees (Vončina et al., 2015) and other viruses, although to less ratio, additionally justify the setting up the program of clonal selection. Previously, several clones had already been selected within the population of 'Maraska': Sokoluša, Brač 2, Brač 6, Recta, and Vodice 1 (Medin, 1997), but there are no data on their performance, as the war in Croatia discontinued the research.

#### 'Oblačinska' sour cherry.

'Oblačinska' sour cherry is a cultivar of unknown origin, but the first plantation was established near the village of Oblačina in southern Serbia (then within the former Yugoslavia) in 1959 (Pavičević, 1978; according to Puškar, 2005), after which this, until-then unknown cultivar, got its name and started to spread all over former Yugoslavia. Several theories, spread by word of mouth, exist about the origin of 'Oblačinska' sour cherry. According to these theories that are hard to be checked, this genotype was introduced to Oblačina from Vojvodina (northern part of the Republic of Serbia), where it was introduced from middle Dalmatia (Croatia), but another theory says it was even introduced from Slovakia. Nowadays it is produced in Serbia, Bosnia, and Croatia.

The main advantages of 'Oblačinska' are easy propagation by the root shoots that eliminate the need for grafting, easy harvesting by hand, and uniform harvest time. On the other hand, a lot of root shoots that require elimination from the space between trees, and the low root system that complicates or even makes impossible mechanical harvesting may be a disadvantage in the plantation. Therefore, 'Oblačinska' sour cherry is suitable for production in areas with a lot of manual labor for harvesting at its disposal. It is also tolerant to soils of

lower quality in some marginal areas and tolerant to diseases and pests. It is a self-compatible cultivar; its fruit is small, rounded, or little flattened with small stone that may be easily separated from the flesh. It is mainly produced for the confectionery and processing industry and traded either as preserved or frozen fruit or in the form of concentrated juice (Mratinić, 2010).

Puškar (2005) assessed genetic, pomological morphological, and chemical variability among 42 biotypes chosen according to morphological characteristics observed in situ. These plants were propagated and planted side by side in one plantation under uniform agrotechnical and micro-environmental conditions on CAB 6P rootstock. Seven genotypes (biotypes) were significant by economic and pomological value giving them the potential for further propagation and official recognition as clones. Viljevac (2012) assessed the drought tolerance of several sour cherry clonal candidates and concluded 'Oblačinska' is significantly tolerant comparing to 'Keleris 16', 'Cigánymeggy', and even to 'Maraska' which is grown in the Mediterranean region, a climatic zone with more significant lack of rains during the time of flower bud set.

### **Sweet cherry**

The long tradition of sweet cherry production in Croatia does not mean that all contemporary principles of growing have been applied. Until recently, the production of sweet cherry was limited mainly to solitary trees grown in the gardens and house yards, grafted to non-selected and self-growing vigorous *P. mahaleb* and *P. avium* rootstock. The expansion of commercial production, more significant since 2000, goes together with more attention given to new technologies, including less vigorous and dwarfing rootstocks (Santa Lucia, Colt, Gisela 5 and Gisela 6) pruning technics, training systems, protection against diseases, and pests, fertigation, but also on marketing and trade distribution of cherry fruit. Contrary to traditional production based on traditional European and international ('Van', 'Lambert', 'Bing', 'Ferrovia', 'Germersdorfer') and native cultivars described below, new orchards are established after the introduction of technologically superior cultivars like 'Kordia', 'Early Burlat', 'New Star', 'Lapins', 'Garnet' in plantations with an increased tree density of 600-1000 trees ha<sup>-1</sup> (Biško et al., 2017). These new orchards have been established mainly with self-pollinated cultivars, putting old native cultivars in the rank of less important. However, all native and local cultivars should be preserved as cultivars of unique value significant for the area they have been produced. In 2016, the total production of sweet cherries in Croatia was 1907 t, but in the period 2012-2016, the quantity varied between 1552 and 6241 t (Croatian Bureau of Statistics, 2016).

### **1. Historical overview of sweet cherry cultivars.**

The tradition of sweet cherry production in Croatia may be illustrated by the ancient literature published in the second half of XIX<sup>th</sup> and the beginning of the XX<sup>th</sup> century, where some sweet cherry varieties are listed. The most ancient book about fruit culture (Veselić, 1848) does not mention cultivars by name but provides a classification of sweet cherries by the texture of fruit (soft or hard-flesh) and the time of ripening (early or late). The first author who mentioned varieties by name was Trumer (1881). He listed several cultivars, mainly by German names, such as 'FrüheMaiherzkirsche', 'BüttnersschwarzeHerzkirsche', 'Fromm's', 'Krügers', 'Winklers', 'Tilgeners', 'Elton', 'Adams', 'JahnsDurchsichtige', 'Flamentiner', etc. The subsequent sources (Kuralt, 1884, 1900) specify more or less the same cultivars, with few drop-outs and newly added varieties, some of them widely known today, like 'Hedelfingen' (Ožanić, 1903; Radić, 1909). Only a few of these old cultivars, like 'Büttners', 'Winklers' and 'Elton' are listed in *S*-allele compatibility tables (Tobutt et al., 2004). We assume the other cultivars either disappeared after being substituted by new cultivars or retained the status of local cultivars of small importance. However, in these so-called "ancient" sources we cannot find the names like 'Tugarka', 'Stonska', 'Gomilička' and other cultivars specified as "native" in recent literature published during the 1980s and 1990s, after a long gap of more than 70 years, the period in which the cultivars of sweet cherry were not even mentioned in the horticultural literature, probably for being considered as a marginal crop with almost no

significance. After the mentioned gap, cherry cultivars were described in literature published around the transition years from the XX<sup>th</sup> to XXI<sup>st</sup> century (Poljoprivrednisavjetnik, 1985; Miljković, 1991; Radunić et al., 2007). These new sources list another cultivar common in the XX<sup>th</sup> century like 'Van', 'Germersdorfer', 'Bing', etc., but also several "native" cultivars like 'Tugarka', 'Stonska', 'Gomilička' and others to which we shall focus in this paper. The question is, where do these, "native" cultivars, originate from, and where have the cultivars listed in old literature from the XIX<sup>th</sup> century disappeared? Our theory is that some of the old cultivars had just adopted new names, or they may be synonyms to foreign cultivars introduced and spread without administrative control over the region where they are grown (Duralija et al., 2004). It may be explained as a consequence of the traditional way of propagation without official certification schemes known today. Moreover, the fact that all the native cultivars ('Lovranska', 'Kutjevačka', 'Stonska', 'Tugarka', 'Gomilička', 'Okička', 'Creska') have got their names after specific toponym, which may be town (Lovran, Kutjevo, Ston), village (Tugare), mountain (Okić) or island (Cres) also provoke the question if these cultivars are really 'native' (originating from the area after which they got the name), or they had been introduced and propagated traditionally, adopting the name after the geographic region (town, village, island) they became dominantly producing varieties. If so, that region may be considered as a local center of further spreading of the cultivar.

## 2. The genetic identity and pomological description of sweet cherry cultivars.

All the assumptions discussed in the previous chapter mean that many of these cultivars might be synonyms one to another, or synonyms to any introduced cultivar. The partial answer about "native" sweet cherry cultivars may be found in the fact that some of "native" cultivars ('Tugarka', 'Lovranska', 'Creska' and 'Kutjevačka') are synonyms, as determined by SSR molecular analyses on ten microsatellite loci (Vokurka, 2012). This conclusion is supported by the determination of  $S_3S_{12}S$ -allele genotype in four cultivars ('Tugarka', 'Creska', 'Lovranska', and 'Kutjevačka') (Vokurka, 2012; Ercisli et al., 2012), and additionally confirmed (Vokurka, 2017, unpublished data) by DNA analyses on additional 16 microsatellite loci suggested by Clarke and Tobutt (2009). Taking into account the high morphological similarity of these cultivars, we shall consider them as synonyms. All the previous discussions in the literature on these four cultivars as unique may be explained by environmental influence, pomological and morphological research performed in situ, and the lack of systematic study with parallel trial and homogenous conditions and uniform rootstocks. The  $S$ -allele composition narrows the candidates for synonymy among cultivars from  $S_3S_{12}$  group, like the most widespread Turkish variety 'Ziraat 0900', Italian 'Ferrovia', or German 'Nordwunder' 'Schneiders Späte Knorpelkirsche' or 'Germersdorfer' (Hungarian 'Germersdorfi'), if not any of the other 21 less known varieties from the same group, as systematized by Schuster, (2012). This still does not mean they are synonyms until further microsatellite analyses confirm or confute these speculations.

### *'Creska' and its synonyms ('Lovranska', 'Tugarka', and 'Kutjevačka').*

These cultivars are, as discussed above, synonyms and should be considered as the same cultivar. According to own observations (Vokurka, 2012; Vokurka et al., 2014), and other sources (Miljković, 1991; Radunić et al., 2008) it has a big fruit of cordate shape, long stalk, ripening time is late or very late depending on the producing area. It is hard to determine ripening time relatively to 'Lambert' as any comparisons in trials have not been performed. The main quality of this cultivar is the transportability of fruits, good balance of sugar and acid and excellent aroma, dark red color, and relatively big fruit, although on a rather long stalk. Their production is concentrated around Croatian towns (Lovran, Kutjevo) and village (Tugare) after the three synonyms are named.

### *'Gomilička'*

This cultivar is named after Kaštel Gomilica, one of seven small towns in middle Dalmatia. According to present knowledge, it is a unique cultivar with no detected synonyms (Vokurka, 2012; Ercisli et al., 2012). The value of this cultivar is early ripening, at the

beginning of May. Although the fruits are soft, juicy, non-transportable, and rather small to middle-sized (Vokurka, 2012; Vokurka et al., 2014), as the first ripening cultivar of high contents of sugar and dark red color, it is quite appreciated by consumers. It is mainly sold in the local fresh markets. It is a self-incompatible cultivar.

#### *'Stonska'*

'Stonska' is also a cultivar produced mainly in middle Dalmatia, although its name is derived from the town of Ston in Southern Dalmatia. It has relatively big fruit, rounded with a small hole on the pistilar end. The firm flesh enables transportability away from local markets. It ripens in the period after 'Gomilička' and before 'Tugarka'. The juiciness of the flesh is medium, but the sugar content is very high, with moderate acidity. The petal is medium thick and long, while the stone is of middle-size comparing to the size of the fruit. It is self-incompatible and has a unique SSR profile (Vokurka, 2012).

#### *'Okička'*

'Okička' sweet cherry is produced in the north-western part of Croatia and got its name after the mountain 'Okičkagora' in the north-western part of Croatia. The main economic value of this cultivar isolates ripening time, almost at the beginning of July. Its genetic profile is unique and does not have any detected synonyms. The fruit is small to a middle-sized and rounded shape, the flesh is firm, less juicy, very sweet, and aromatic with moderate acidity. It is a self-incompatible cultivar (Vokurka, 2012).

## CONCLUSIONS

The most important sour cherry cultivars in Croatia ('Maraska' and 'Oblačinska') are diverse populations, genetically very close, similar on the level of molecular genetics, but they are different varieties, adapted to different climatic conditions. Their comparative advantages are adaptability to climatic and soil conditions that sometimes have characteristics of marginal, like high summer temperatures, drought during the vegetation season, low spring temperatures during the time of flowering. The unique quality and aroma of 'Maraska' products is a result of the genetic potential of the cultivar and its interaction with unique climatic and karst conditions in Dalmatia. Populations of both varieties ('Maraska', and 'Oblačinska') may be a good resource for clonal selection, as concluded according to bad sanitary status regarding infection with plant viruses, but also the existence of morphological, pomological, and chemical variability detected within their populations. To improve the output of production, a clonal selection program should be established.

Four Croatian cultivars of sweet cherry ('Lovranska', 'Tugarka', 'Creska', and 'Kujevačka') considered in the literature as "native" until now, are synonyms i.e., they have identical genotypes on 26 microsatellite loci, and the same *S*-allele constitution ( $S_3S_{12}$ ). Further genetic analyses should clear if these varieties are synonyms to any of the other cultivars with  $S_3S_{12}$  incompatibility allele constitution, like 'Ziraat 0900', 'Ferrovia', 'Nordwunder', 'Schneiders Späte Knorpelkirsche' or 'Germersdorfer'. The production of these cherries is mainly concentrated in the surroundings of towns, villages, or islands where it is produced, and they are also named after these geographical sites. With time, these cherries have become an element of the tradition, recognizability, and cultural branding of these places. It may remain so, i.e., the market name of these cherries may remain as it is now, but the production of planting material may be simplified operationally, taking into account these cultivars are synonyms.

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