



Variability in physical and chemical characteristics of Cornelian cherry fruits (*Cornus mas* L.) from Romanian Oltenia region's spontaneous flora and role of the climatic conditions

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Abstract

High variability in populations of Cornelian cherry (*Cornus mas* L.) from spontaneous flora is an important genetic source for propagation and breeding programs. This study aimed to provide information on the state of genetic resources in *C. mas* in Romania and on physical–chemical characteristics of fruits in selected genotypes. Over 2 years of study, significant differences in morphometric characteristics were observed. Notably, fruit weight and pulp percentage varied between 1.0 and 2.67 g and between 66.71 and 90.02%, respectively, and a high variability in chemical composition of fruit pulp among population was also observed. The relationships between different morphometric characteristics of fruits confirmed the influence of fruit size on the fruit weight and pulp percentage. Selection and study of *C. mas* L. genotypes in Oltenia region's spontaneous flora was shown to be useful for introducing the most valuable selections in commercial exploitation.

Keywords *C. mas* L. · Germplasm · Traits variability

1 Introduction

Cornelian cherry (*Cornus mas* L.) is a species with food value owing to its fruits quality (Brindza et al. 2009; Sochor et al. 2014); fruits are consumed fresh and canned, as alcoholic beverages and other traditional produce (Rop et al. 2010), and also as medicinal remedy (Seeram et al. 2002; Ercisli 2004a; Rop et al. 2010). *C. mas* is also a decorative species owing to its yellow flowers and early flowering time (Ercisli 2004b). It is also used to protect the environment by fixing the soil and preventing erosion due to its basal shoots growing capacity (Prokaj et al. 2009). *C. mas* genotypes vary greatly in terms of fruit productivity and characteristics, such as size, shape, colour, flavour and nutritional value. High genetic diversity in *C. mas* is due to its generative reproduction. Full evaluation of genetic resources in spontaneous flora is essential for selecting the genotypes with valuable characteristics that are useful for future propagation and

breeding programs, designed to introduce into crop cultivars the desirable features such as ability to adapt to continuous changing climate conditions and the resistance to diseases of spontaneous flora genotypes (Bijelic et al. 2007; Ercisli et al. 2008; Hassanpour et al. 2012; Imani and Rad 2015). However, there are quite few studies in Romania on *C. mas* selection (Ancu et al. 2012; Cornescu and Cosmulescu 2017; Cornescu Fratutu and Cosmulescu 2019). In other countries, selection studies have long been initiated in Russia (Rudkovsky 1960), Yugoslavia (Krgovic 1987), Ukraine (Guleryuz et al. 1996; Klimenko 2004) and they are continuing in Turkey (Ercisli 2004b), Serbia (Bijelic et al. 2011a, b), Czechia (Rop et al. 2010; Sochor et al. 2014), Iran (Hassanpour et al. 2012; Imani and Rad 2015). In order to avoid biodiversity loss, it is necessary to collect and preserve genotypes with high variability and adaptability to environmental conditions (Mratinic et al. 2015). Genetic preservation of *C. mas* will be essential for development of productive cultivars that are appropriate to the needs of commercial producers and small farmers (Klimenko 2004). Knowledge of genetic diversity in *C. mas* is important for assessing the adaptability of genotypes to environmental conditions in different regions (Yilmaz et al. 2009).

Considering the information presented above, this study aimed to provide information on the state of *C. mas* genetic

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resources in the South-West area of Romania and also on physical and chemical characteristics of fruits in genotypes selected from different local populations in spontaneous flora.

2 Materials and methods

Study material – The study was conducted on 29 Cornelian cherry genotypes (*Cornus mas* L.) selected from spontaneous flora, 14 of Calaparu population (C1, ..., C14), Gorj County and 15 of Eselnita population (E1, ..., E15), Mehedinți County. Fruits were harvested at full maturity (2017 and 2018 crop) and carried to the laboratory for physical–chemical analysis. Data regarding climatic conditions during the study period/years 2017–2018 are presented in Table 1.

Physical characteristics – The study was conducted on 50 randomly selected fruits from each selected genotype. Biom-etric measurements of fruits were carried out, following-up the fruit weight, fruit height, larger diameter and smaller diameter of fruits, kernel weight, according to the methodology described by Imani and Rad (2015), Ionica et al. (2018).

Chemical characteristics – Total acidity (TA) determination was performed using the method described by Ionica et al. (2018). Expression of results was done in ml NaOH *n*/10/100 grams of fresh substance. For determination of total dry substance (SUT), a method based on water elimination by

evaporation from average analytical sample was used, keeping it in an oven at temperatures of 85–105 °C. Expression of results was made as a percentage of total dry substance. Soluble dry substance (SUS) was determined by refractometric method. Expression of results was made as a percentage of soluble dry substance. For each sample, three determinations were conducted, and the final result was given by their average value.

Statistical analysis – The data obtained were statistically processed using the descriptive statistical program (StatPoint Technologies, Warrenton, VA, USA). The relationships between physical characteristics of fruits were quantified using the correlations.

3 Results and discussion

High variability in spontaneous flora is an important source of genetic resources for use in propagation and breeding programs (Bijelic et al. 2012). Tables 2 and 3 show that a high variability of all fruit characteristics both within the population and among the populations, and these fruit characteristics depended on the climatic year. The highest variation coefficient for the average fruit height (7.78%) was calculated for genotypes of Eselnita population in 2018. Variation limits for the average fruit height were between 11.95 mm (E16) in 2018 and 15.86 mm (E2) in 2017. The results are lower than those obtained in Iran by Hassanpour et al. (2012): 15.22–22.31 mm; Imani and Rad (2015): 14.8–24.0 mm,

Table 1 Geographical coordinates and climatic factors in research area

Populations	Geographical coordinates			Yearly mean temperature (°C)	Monthly mean rainfall (mm)
	Latitude	Longitude	Altitude (m)		
Eselnita	44° 42' 7" N	22° 21' 48" E	86	13.25–13.42	317.3–463
Calaparu	44° 41' 4" N	23° 17' 3" E	155	12.42–12.50	295.62–370.8

Table 2 Variability of physical characteristics of Cornelian cherry fruits (*Cornus mas* L.) in analyzed populations

Characteristics	Statistical analysis	Eselnita (<i>n</i> = 15)		Calaparu (<i>n</i> = 14)	
		2017	2018	2017	2018
Height (<i>H</i> ; mm) ^a	Mean ± SD	15.07 ± 0.46	14.07 ± 1.09	15.34 ± 1.15	15.67 ± 0.84
	Variation limits	14.09–15.86	11.95–15.33	12.81–17.04	14.26–16.92
	CV%	3.06	7.78	7.50	5.37
Larger diameter (<i>D</i> ; mm)	Mean ± SD	11.50 ± 0.48	9.80 ± 0.76	9.21 ± 1.07	11.11 ± 0.77
	Variation limits	10.63–12.18	8.97–11.41	7.79–10.96	10.03–12.54
	CV%	4.19	7.76	11.59	6.95
Smaller diameter (<i>d</i> ; mm)	Mean ± SD	11.01 ± 0.49	9.32 ± 0.81	8.83 ± 1.02	10.67 ± 0.77
	Variation limits	10.13–11.73	8.51–11.13	7.42–10.52	9.61–12.20
	CV%	4.46	8.74	11.53	7.22

^aValues represent average of 50 fruits/genotype/population

Table 3 Variability of quantitative characteristics of Cornelian cherry fruits (*Cornus mas* L.) in analyzed populations

Characteristics	Statistical analysis	Eselnita (<i>n</i> = 15)		Calaparu (<i>n</i> = 14)	
		2017	2018	2017	2018
Fruit weight (Gfr; g) ^a	Mean ± SD	2.32 ± 0.08	1.63 ± 0.27	1.49 ± 0.34	2.00 ± 0.37
	Variation limits	2.18–2.43	1.15–2.16	1.00–2.08	1.56–2.67
	CV%	3.39	16.61	22.78	18.58
Pulp weight (Gp; g)	Mean ± SD	1.92 ± 0.07	1.32 ± 0.29	1.12 ± 0.30	1.71 ± 0.38
	Variation limits	1.80–1.99	0.89–1.92	0.67–1.62	1.25–2.42
	CV%	3.49	21.65	26.60	22.00
Kernel weight (Gs; g)	Mean ± SD	0.40 ± 0.02	0.31 ± 0.05	0.38 ± 0.08	0.28 ± 0.04
	Variation limits	0.39–0.44	0.24–0.39	0.27–0.58	0.22–0.37
	CV%	4.16	15.48	20.78	15.08
Percentage (Pp; %)	Mean ± SD	82.55 ± 0.41	80.08 ± 4.53	73.72 ± 4.85	85.05 ± 3.46
	Variation limits	81.76 ± 83.27	72.62 ± 88.40	66.71 ± 79.90	78.17 ± 90.02
	CV%	0.49	5.66	6.58	4.06

^aValues represent average of 50 fruits/genotype/population

in Turkey by Yilmaz et al. (2009): 14.8–31.1 mm, and in Slovakia by Brindza et al. (2009): 12–19.5 mm. The lowest value and highest value of the larger diameter of fruits were recorded in genotypes of Calaparu population, namely 7.79 mm (C17) in 2017 and 12.54 mm (C15) in 2018. The results obtained are comparable to those reported by Brindza et al. (2009) in Slovakia (7.40–15.20 mm), by Hassanpour et al. (2012) in Iran (10.26–16.3 mm), Imani and Rad (2015) in Iran (10.8–16.0 mm) and by Cornescu and Cosmulescu (2017) in Romania (8.85–14.66 mm). The smaller diameter of fruit has also varied from year to year within the same population, but also from one population to another within the same climatic year, the variation limits for this characteristic being between 7.42 mm (C17) in 2017, and 12.20 mm (C15) in 2018. Cornescu and Cosmulescu (2017) reported variation limits for the smaller diameter of Cornelian cherry fruit from local populations in Romania, ranging from 8.36 to 14.33 mm.

Selection of *C. mas* should focus primarily on the fruit weight, this characteristic having the highest direct correlation with the pulp weight (Karadeniz 2000; Bijelic et al. 2007). The fruit weight, the most important commercial feature, was averaged 2.32 g in 2017 and 1.63 g in 2018 in Eselnita population, while in Calaparu population the average was 1.49 g in 2017 and 2.0 g in 2018 (Table 3). The largest fruit was found in genotype C15 (2.67 g) in 2018, while the smallest (1.0 g) in C3 genotype in 2017. The results obtained are higher than those reported by Tural and Koca (2008) in Turkey (0.39–1.03 g) and are similar to those reported by Drkenda et al. (2014) in Bosnia Herzegovina (1.8–2.60 g). Results related with *C. mas* fruit weight were also reported by other researchers. In Turkey, Ercisli (2004b), Ercisli et al. (2006) and Yilmaz et al. (2009) reported fruit weight between 1.0–6.5 g, 1.46–3.81 g and 1.40–9.2 g. In Slovakia, Brindza et al. (2009) reported

0.5–3.40 g fruit weight, and Bijelic et al. (2011a) reported 2.11–6.71 g fruit weight in Serbia. Moreover, fruit weighted ranged between 1.49 and 3.29 (Hassanpour et al. 2012) and 1.57–3.52 g (Imani and Rad 2015) in Iran.

The pulp weight varied between 0.67 g (C3) in 2017 and 2.42 g (C15) in 2018, while the kernel weight was between 0.22 g (C3) in 2018 and 0.58 g (C15) 2017. In Iran, Imani and Rad (2015) and Hassanpour et al. (2012) reported pulp weight and kernel weight between 1.26–3.01 g, 0.27–0.64 g and 1.25–2.94 g, 0.24–0.42 g, respectively. The pulp percentage is, after fruit weight, the most important feature of Cornelian cherry fruits for selection (Drkenda et al. 2014). The pulp percentage varied between 66.71% (C17) in 2017 and 90.02% (C15) in 2018. The lower limit is lower than that reported by Ercisli et al. (2006) in Turkey, respectively 79% and by Bijelic et al. (2011a) in Serbia, respectively 78.52%, while the upper limit is higher than that reported by the two researchers: 88% and 88.74%, respectively. The scale proposed by Imani and Rad (2015) was used for classification of genotypes in terms of fruit characteristics (Table 4). In Eselnita population, 8 genotypes had small fruits and 7 genotypes had medium fruits. The fruit shape was oval with a shape index comprised between 1.30 and 1.44, except for the E3 and E15 genotypes that had elongated shape fruit with a shape index of 1.45 and 1.46. All the fruits of genotypes in this population had a large kernel. In Calaparu population, 12 genotypes exhibited small fruits and two (C5 and C15) showed medium-sized fruits, 11 genotypes had oblong shaped fruits with a shape index of 1.48 to 1.71, and three genotypes (C1, C5, C11) showed oval shaped fruit with a shape index of 1.41, 1.42 and 1.44, respectively. Eleven of the 14 genotypes had fruits with large kernel, 2 had medium size kernels (C3, C9), and 1 genotype (C15) showed very large kernels. Imani and Rad (2015) showed that most of the Cornelian cherry fruits analyzed in Iran had oval to elongate

Table 4 Classification of genotypes in terms of fruit characteristics

Genotype	Eselnita						Genotype	Calaparu					
	Gfr	Size	Gs	Size	IF	Shape		Gfr	Size	Gs	Size	IF	Shape
E1	2.19	Me	0.33	Ma	1.30	O	C1	1.83	Mi	0.35	Ma	1.41	O
E2	2.29	Me	0.34	Ma	1.44	O	C2	1.36	Mi	0.32	Ma	1.55	A
E3	2.02	Me	0.36	Ma	1.45	A	C3	1.37	Mi	0.28	Me	1.54	A
E4	1.83	Mi	0.36	Ma	1.34	O	C4	1.83	Mi	0.34	Ma	1.62	A
E5	1.67	Mi	0.33	Ma	1.34	O	C5	2.02	Me	0.36	Ma	1.44	O
E6	1.83	Mi	0.39	Ma	1.44	O	C6	1.57	Mi	0.34	Ma	1.66	A
E7	1.94	Mi	0.38	Ma	1.42	O	C7	1.74	Mi	0.32	Ma	1.62	A
E8	1.98	Mi	0.38	Ma	1.30	O	C8	1.99	Mi	0.31	Ma	1.52	A
E9	1.96	Mi	0.35	Ma	1.36	O	C9	1.49	Mi	0.28	Me	1.60	A
E10	1.91	Mi	0.36	Ma	1.40	O	C11	1.90	Mi	0.36	Ma	1.42	O
E11	2.06	Me	0.38	Ma	1.40	O	C13	1.52	Mi	0.31	Ma	1.61	A
E12	2.04	Me	0.33	Ma	1.42	O	C14	1.89	Mi	0.35	Ma	1.58	A
E13	2.08	Me	0.37	Ma	1.37	O	C15	2.27	Me	0.41	Fm	1.48	A
E15	2.03	Me	0.33	Ma	1.46	A	C17	1.62	Mi	0.32	Ma	1.71	A
E16	1.72	Mi	0.35	Ma	1.34	O							

Values represent the average over the years 2017 and 2018/genotype

Gfr fruit weight, Gs kernel weight, IF shape index, Me medium, Ma large, Mi small, Fm very large, O-Oval A-elongated

shape, but they may also have spherical shape. Hassanpour et al. (2012) reported a shape index ranging from 1.19 to 1.51. Variation limits for the shape index ranging from 1.81 to 2.35 have been reported by Demir and Kalyoncu (2003); Turhan et al. (2007); Bijelic et al. (2011a).

The relationships between morphometric characteristics of fruits in Eselnita population (Table 5) revealed high positive correlations between fruit weight and small diameter ($r=0.83$), the fruit weight and fruit height ($r=0.81$), the fruit weight and the larger diameter ($r=0.78$), between pulp weight and fruit weight ($r=0.99$), between the pulp percentage and the pulp weight ($r=0.91$), and the pulp percentage and fruit weight ($r=0.85$). In Calaparu population (Table 6), the highest correlations were calculated between fruit weight and larger diameter ($r=0.86$), fruit weight and smaller diameter ($r=0.85$), and between pulp percentage and pulp weight

($r=0.67$). Hassanpour et al. (2012) reported similar correlations between different morphometric characteristics of fruit: $r=0.99$ between the fruit weight and pulp weight, $r=0.87$ between the fruit weight and its height, and $r=0.88$ between the pulp weight and fruit height. In analyzing the correlations between morphometric characteristics of fruits, it was found that fruit weight and the pulp percentage are largely influenced by the fruit size. The high variability of Cornelian cherry genotypes characteristics in the analyzed populations offers the opportunity of selecting genotypes with superior characteristics and adapted to local climatic conditions. Kim et al. (2003) stated that the variability of fruit characteristics can be influenced by genotype. *C. mas* fruits in Oltenia region's spontaneous flora are an important source of antioxidants and genetic resources that are useful in propagation and breeding programs (Cosmulescu et al.

Table 5 Correlations between fruit characteristics of genotypes in Eselnita population

Characteristics ^a	H	D	d	Gfr	Gp	Gs	Pp
H	1.00						
D	0.70	1.00					
d	0.73	0.99	1.00				
Gfr	0.81	0.78	0.83	1.00			
Gp	0.81	0.79	0.84	0.99	1.00		
Gs	-0.06	-0.20	-0.25	-0.11	-0.23	1.00	
Pp	0.69	0.70	0.76	0.85	0.91	-0.59	1.00

H height, D larger diameter, d smaller diameter, Gfr fruit weight, Gp pulp weight, Gs kernel weight, Pp pulp percentage

^aValues represent the average over the years 2017 and 2018/genotype

Table 6 Correlations between fruit characteristics of genotypes in Calaparu population

Characteristics ^a	<i>H</i>	<i>D</i>	<i>d</i>	Gfr	Gp	Gs	Pp
<i>H</i>	1.00						
<i>D</i>	0.67	1.00					
<i>d</i>	0.67	1.00	1.00				
Gfr	0.70	0.86	0.85	1.00			
Gp	0.71	0.84	0.83	1.00	1.00		
Gs	0.60	0.77	0.77	0.79	0.74	1.00	
Pp	0.54	0.57	0.58	0.63	0.67	0.16	1.00

H height, *D* larger diameter, *d* smaller diameter, *Gfr* fruit weight, *Gp* pulp weight, *Gs* kernel weight, *Pp* pulp percentage

^aValues represent the average over the years 2017 and 2018/genotype

2018). Chemical characteristics of *C. mas* fruit (Table 7) showed that the total dry substance ranged from 23.66% (E12) and 27.56% (E6) in genotypes of Eselnita population, and between 27.60% (C6) and 40.11% (C3) in genotypes of Calaparu population. Variation limits for soluble dry matter are between 13% (E2) and 20% (E5) in Eselnita population, and between 21.20% (C6) and 36.90% (C8) in Calaparu population; and as total acidity it were between 240 and 360 ml NaOH *n*10 100 g-1 (E2–E8) in genotypes of Eselnita population, and between 185 and 395 ml NaOH *n*10 100 g-1 (C8–C11) in genotypes of Calaparu population.

The results obtained are consistent with those in the literature. Bijelic et al. (2011b) reported variation limits for total dry substance ranging from 18.26 to 33.39% and for dry soluble substance ranging from 17.40 to 32.37% in genotypes selected in Serbia. Sochor et al. (2014) reported a maximum dry substance content of 17.40% and a soluble dry matter of 15.8% for genotypes selected in Czechia. Ercisli et al. (2011) reported a total dry substance value ranging from 12.60 to

21.06%. Hassanpour et al. (2012), analyzing the chemical composition of several Cornelian cherry genotypes in Iran, have reported values between 5 and 12.5% for the soluble dry substance, and between 0.43 and 1.86% for total acidity.

In summary, the high variability in the analyzed characteristics of *C. mas* populations offered the opportunity of selecting genotypes with superior characteristics and adapted to local climatic conditions. Notably, fruit weight and pulp percentage varied between 1.0 and 2.67 g and between 66.71 and 90.02%, respectively, and a high variability in chemical composition of fruit pulp from one population to another was also observed. The relationships among different morphometric characteristics of fruits confirmed the influence of fruit size on the fruit weight and pulp percentage. Selection and study of *C. mas* genotypes in Oltenia region’s spontaneous flora was shown to be useful for introducing the most valuable selections in commercial exploitation.

Table 7 Chemical properties of fruits in Cornelian cherry genotypes (*Cornus mas* L.) in analyzed populations

Statistical analysis	Eselnita			Calaparu		
	SUT (%)	SUS (%)	TA (ml NaOH <i>n</i> /10/100 g)	SUT (%)	SUS (%)	TA (ml NaOH <i>n</i> /10/100 g)
Mean	25.21	16.87	306.67	33.54	27.50	316.79
Standard deviation	1.12	2.01	30.16	3.89	4.76	63.20
Minimum	23.66	13.00	240.00	27.60	21.20	185.00
Maximum	27.56	20.00	360.00	40.11	36.90	395.00
CV%	4.45	11.94	9.83	11.59	17.30	19.95

SUT total dry substance, *SUS* total soluble substance, *TA* titrable acidity

Author contribution statement SC and FC originally formulated the idea, FC developed methodology, SC conducted fieldwork, SC and FC wrote the manuscript.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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