NUTRITIONAL VALUE OF *ROSA SPP.* L. AND *CORNUS MAS* L. FRUITS, AS AFFECTED BY STORAGE CONDITIONS

CRAITA–MARIA ROŞU[1*], ZENOVIA OLTEANU[2], ELENA TRUŢĂ[1], ELENA CIORNEA[2], CIPRIAN MÂNZU[2], MARIA–MAGDALENA ZAMFIRACHE[2]

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Abstract: A comparison between two storage methods (freezing and drying) of fruits, in terms of ascorbic acid, carotenes, total sugar and protein content in *Rosa* spp. L. species and *Cornus mas* L. was performed. In the dried rose hips, the major losses were registered at the level of ascorbic acid content (32.04–50.25 %), followed by carotenes (30.85–52.08 %), total sugar (21.57–34.6 %) and protein content (21.33–46.89 %). The freezing method resulted in a better preservation of ascorbic acid (only 19.80–29.21 % decrease) and total sugar content (3.41–12.94 % increase). In the preserved cornelian cherry fruits, no statistically significant differences were registered between fruits categories, except carotene content, which was dramatically decreased in dried fruits (88.23 %). For cornelian cherry fruits, both storage methods induced a decrease of ascorbic acid and protein contents (57.60 and 46.32 %) and an increase of total sugar level (37.60 %).

INTRODUCTION

Studies regarding the chemical composition of rose hips and cornelian cherry fruits represent an important focus, because of their benefice as food and medicine. The evidence for the health benefits of fruit consumption are found from sources in traditional medicine as well as clinical studies. The positive influence of rose hips has been demonstrated to reduce the risk of cardiovascular diseases (Ninomya,et al., 2007), different form of cancer (Omenn, 1996; Karakaya, 1999; Olsson, 2004) or to promote an anti-inflammatory effect (Winter, 2005; Deliorman *,2007*). Concurrently, cornelian cherry fruits chemical composition has documented positive health benefits, through antidiarrhetic, astringent or febrifuge properties of the fruits (Chiej, 1984) or e.g. in inhibition of tumor cell proliferation by anthocyanins (Vareed, 2006).

Special benefice is derived because of a very rich content of phenols, ascorbic acid, anthocyanin and carotenoid pigments, in the case of rose hips (Hornero–Mendez, 2000; Olsson, 2005; Uglla, 2005; Ercisli, 2007; Nojavan, 2008; Yoruk, 2008; Andersson, 2009; Celik, 2009; Kazaz, 2009; Saeidi, 2009) or cornelian cherry fruits (Oblak*, 1980;* Demir, 2003; Ercisli, 2004; Yilmaz, 2009). Some of these natural compounds have an important contribution to the high total antioxidant activity of rose hips (Gao, 2000) and cornelian cherry fruits (Pantelidis, 2007).

Little information is available in scientific work about absolute or relative change of major nutritive or non-nutritive components in preserved rose hips and cornelian cherry fruits. Taking into account the great sensitivity of these components to storage conditions and the major problem associated with both conservation methods (loss of vitamin C, browning, loss of nutrients, flavor and color changes, because of the oxidative enzymes) we have measured the ascorbic acid, carotenes, total sugars and protein level in fresh, frozen and dried rose hip and cornelian cherry fruits.

The purpose of our study was to appreciate the nutritive value of the fruits preserved by traditional methods, as compared with the fresh fruits, and to establish degree of alteration of these compounds, if a difference exists.

MATERIALS AND METHODS

Sample selection

The high yielded dog rose and cornelian cherry genotypes were selected and collected for experiments from North-East regions of Romania, from altitude of 330 m (*Cornus mas* L.) and between 400–1060 m (*Rosa* spp. L) in the 2008–2009 years. The genotypes were identified according to taxonomical criteria (*26,27*) as *Rosa canina*, *R. subcanina*, *R.corymbifera*, *R. nitidula* and *R. vosagiaca*. Three different genotypes from each rose species were selected for analysis. The cornelian cherry collected genotypes (*N*=10) were all identified as *Cornus mas*.

Sample collection and processing

Selected fruits were harvested at the fully ripe maturity stage for each species, transported in cold containers and short – time stored at 4 ºC for further processing. The fruits were divided into three categories and processed. The fresh fruits belonging to first category were immediately analyzed for ascorbic acid, carotenes, total sugar and protein level. The fruits included in the second and the third categories were processed by freezing and drying, respectively, without any pretreatment, for long-term storage.

For freezing, the fruits were cleaned, packed in polyethylene bags and stored in a domestic freezer at -20 ºC, for a period of four month.

For drying, the fruits were placed in a single layer in a typical food – dehydrator and air - dried, at 60 ºC, for a period of approximately 7 hours in the case of rose hips and few hours more for cornelian cherry fruits, in order to reach fruit moisture content of 5–7 % in rose hips and 8–10 % in cornelian cherry fruits. The dried fruits were stored in a cool, dry and dark place, into airtight plastic container. For each genotype and fruit category, an average sample was constituted, from 25 fruits, randomly chosen, cleaned of seeds or stones and mixed in a blender. Each parameter was measured in three replications. The results were finally expressed as the average (±SE) of three selected genotypes for each species of *Rosa* spp. L. and ten genotypes for *Cornus mas* L.

Dry mass

The dry mass of the fruit flesh was gravimetrically determined after drying the samples 4–6 hours in an air–oven, at 105 ºC, to constant weight. The dry mass (DM) percent in samples was calculated according with Boldor (1983) .

Moisture content (percentage dry basis)

The moisture content of fresh and preserved fruit was calculated on dry basis and expressed as percentage (PMS_{db}) (Table 1), according to Koyuncu (2007) formula, but with modified names of indicators:

$PMS_{db}= [M_o–M_d/M_d] \times 100$ /1/

The indicators used in the formula were the initial mass (g) of undried product (M_0) and the dry mass (g) in product W_d.

Table 1. Moisture content (dry basis %) of *Rosa* spp. L. and *Cornus mas* L. fruits used for analysis

Species	Fresh	Frozen	Dried
	moisture %		
Rosa canina	213.38	187.27	6.00
Rosa subcanina	196.29	183.68	5.50
Rosa corymbifera	176.70	168.31	5.26
Rosa nitidula	155.29	153.78	4.86
Rosa vosagiaca	150.37	145.15	6.49
Cornus mas	327.53	314.42	9.12

Determination of ascorbic acid content

The acid ascorbic content was titrimetrically estimated with 2.6–dichlorophenol indophenol solution (Artenie and Tanase, 1981). Results were expressed as mg of ascorbic acid per 100 g.

Determination of carotene content

Briefly, 0.2–0.3 g fruits were first homogenized with a mixture of anhydrous sodium sulphate and calcium oxide, to retain water and the colored compounds from plant tissue, except carotenes. Also, anhydrous sodium carbonate was added, to prevent the carotene decomposition in acid medium. The homogenized fresh and frozen samples were extracted for 15–20 min with acetone (5 mL). The solid residues were decanted and 10 mL of petroleum ether were added to acetone extract. The upper phases dissolved in ether were taken, mixed with 0.5–1.0 g calcium phosphate, filtered and completed to final volume of 100 mL with petroleum ether. Separately, the finely ground dried samples were extracted into a mixture of acetone and n-hexane (3:7), at room temperature, in dark place, for 15 -24 hours.

Extract samples were measured at 450 nm with a Shimadzu UV–1700 Pharma Spec UV–VIS Spectrophotometer, East Lyme, Connecticut, USA. Carotene content was based on the extinction coefficient of a 2.5 mM potassium dichromate standard solution corresponding to 0.00416 mg carotene/mL solution (Artenie and Tanase, 1981). The carotene content was expressed as mg carotene per 100 g.

Determination of total sugar content

The total sugars in fruits were determined as total reducing sugars by colorimetry. The assay was done through hydrolysis in 20 % HCl of aqueous extract of samples in 200 mL glass bottles, and placed for 3 hours in boiling water. Then, the bottles were cooled at room temperature and filtered through Whatman no.4 filter paper. Total reducing sugar was quantified using 3.5–dinitrosalycilic acid method (Miller, 2002). Glucose monohydrate solution (30–300 µg/mL) was used as standard. Absorbance of samples and standard was measured at 500 nm with a Shimadzu UV–1700 Pharma Spec UV–VIS Spectrophotometer, East Lyme, Connecticut, USA. The glucose concentration of the samples was determined by comparing the absorbance of the sample to the absorbance of the glucose standard and expressed as g glucose per 100 g.

Determination of soluble protein content

The soluble protein content in fresh and stored samples was determined according to the Bradford (1976) procedure. The results were expressed as g protein per 100 g.

Statistical analysis

Statistical analysis of the data (expressed on dry mass basis) was carried out by an analysis of variance (Anova) with statistical significance level fixed at $p< 0.05$, completed with Tukey' s multiple range test for comparison of means between fruit categories for each genus, using the statistical analysis software XLSTAT–Pro, Addinsoft, New York, USA.

RESULTS AND DISCUSSION

Ascorbic acid content

In the investigated rose species, collected from North-East region of Romania, we found a high level of ascorbic acid content in fresh fruits, with some variations depending on species. On the dry mass basis, the values ranged between 3473.79 mg/100 g DM (*Rosa subcanina*) and 2517.30 mg/100 g DM (*Rosa nitidula*).

Depending on storage conditions, ascorbic acid content in rose hips decreased after four month, statistically significant ($p\leq0.001$) compared with the level quantified in the fresh fruits, expressed on dry mass basis and used as reference (Table 2). In the frozen rose hips, ascorbic acid level decreased with 19.80–28.12 % (*Rosa nitidula* to *Rosa canina*) compared with the fresh fruits, until registered values of 2018.77 mg/100 g DM (*R. nitidula)* and 2595.05 mg/100 g DM (*R. subcanina*), respectively. The vitamin C alteration degree was found to be higher in the dried fruits where ascorbic acid content decreased in a range between 32.04–50 % (*R. subcanina–R. vosagiaca*) compared with the fresh one, until the quantified values of 1478.66 mg/100 g DM (*R. nitidula)* and 2360.77 mg/100 g DM (*R. subcanina*).

Even with that change, the content of ascorbic acid in preserved fruits is high and confirmed the utilization of rose hips as a major source of vitamin C in natural supplements, a fact also proved by other studies (Yavru, 1997).

In the case of fresh cornelian cherry fruits, an average content of 419.08 mg/100 g DM was determined**.** The reduction of ascorbic acid content was significantly higher in frozen fruits (57.60 %) than in dehydrated ones (45.39 %), comparatively with the fresh fruits ($p\leq0.0001$); the vitamin C level was of 177.69 mg/100 g DM and 228.82 mg/100 g DM, respectively and no statistically differences between the two categories of conserved fruits were evidenced.

The significance of drying condition was mentioned, for example, by Del Caro *et al*. (2004) in the case of prunes dried at low temperature (60 $^{\circ}$C) which had a higher content of ascorbic acid than the fruits dried at high temperature (85–70 $^{\circ}$C). In the case of analyzed cornelian cherry fruits, Koyuncu *et al*. (2007) determined that a temperature of 70 $^{\circ}$C is optimal for freshly harvested cornelian cherry fruits to be dried.

Referring to the quality characteristics of frozen fruits, with respect to ascorbic acid content, the available literature mentioned the strong influence of the freezing temperature upon active compounds integrity. At –12, –18 and –24 $^{\circ}$C, Sahari *et al*. (2004) founded that the major losses of ascorbic acid content in frozen strawberries, occurred during the first 15 days of storage, at the percentage of 64.5, 10.7 and 8.9 %, respectively, and concluded that storage temperatures of -18 and – 24 $^{\circ}$C are the best for preserving the qualitative characteristics.

Table 2. The influence of the storage methods on ascorbic acid content (dry mass basis) in *Rosa* spp. L. and *Cornus mas* L. fruits

Species	Fresh fruits	Frozen fruits	Decrease %	Dried fruits	Decrease %
	Ascorbic acid [mg/100g DM]				
Rosa canina (*N*=3)*	(3263.23±212.97)^{c}	(2345.43±155.25)^{b}	29.21	(1917.26±327.84)^{a}	41.24
Rosa subcanina (*N*=3)	(3473.96±103.11)^{c}	(2595.05±239.18)^{b}	25.29	(2360.76±292.64)^{a}	32.04
Rosa corymbifera (*N*=3)	(2833.06±137.76)^{c}	(2070.13±124.69)^{b}	26.92	(1643.90±172.03)^{a}	41.97
Rosa nitidula (*N*=3)	(2517.30±33.65)^{c}	(2018.77±143.39)^{b}	19.80	(1478.66±33.24)^{a}	41.26
Rosa vosagiaca (*N*=3)	(3216.31±144.72)^{c}	(2423.26±123.10)^{b}	24.65	(1599.91±96.62)^{a}	50.25
Cornus mas (*N*=10)	(419.08±72.59)^{b}	(177.69±39.21)^{a}	57.60	(228.82±84.24)^{a}	45.39

*The values are expressed as means of three or ten replications (±SD)
^{a,b,c} means within the same row followed by different letters are significantly different between groups (fresh, frozen, dried) by Tukey's–HSD test, $p \leq 0.05$

Carotene content

The investigated rose hips contained a total carotene content in a range between 65.02 mg/100 g DM) (*Rosa nitidula*) and 93.59 mg/100 g DM (*Rosa vosagiaca*) (Table 3). According with Razungles *et al*. (1989), in rose hips the carotenes are represented, principally, by β–carotene and lycopene.

The results from processing studies shows us that carotenes content was negatively affected in an equal way in both rose fruit - preserved categories, with no statistically significant differences. In frozen rose hips, after four month of storage, the decreases were in a range between 23.77 (*Rosa nitidula*) and 41.15 % (*Rosa subcanina*), the values being of 49.39 mg/100 g DM and 62.54 mg/100 g DM, respectively. Drying rose hip fruits conducted to an alteration of carotenes content from 30.85 (*Rosa nitidula*) to 52.08 % (*Rosa subcanina*), to values of 44.57 mg/100 g DM and 51.02 mg/100 g DM, respectively.

Total carotene content in fresh cornelian cherry fruits was identified at very low level of 6.58±1.13 mg/100 g DM. The depreciation degree was of 10.33 % and 88.23 % in frozen and dried fruits, the quantified content of carotenes in conserved fruits being of 5.90 mg/100 g DM and 0.77 mg/100 g DM, respectively, with no statistically significant differences between fresh and frozen fruits, but with a dramatically depreciation of the pigment in dried fruits ($p \leq 0.0001$).

Concerning the influence of the storage methods on natural pigments in fruits, the results from literature mentioned, for example, a decrease with only 5.5 % of total carotenoide

content in rose hip juices stored at 4 °C (without oil) for 35 days and a decrease with 40.2 % in pasteurized juice (with dried powder of rose hips).This fact may be explained by the negative effect of drying process, which can harm the antioxidants (Andersson, 2009).

Table 3. The influence of the storage methods on carotenes content (dry mass basis) in *Rosa* spp. L. and *Cornus mas* L. fruits

Species	Fresh fruits	Frozen fruits	Decrease %	Dried fruits	Decrease %
	Carotenes [mg/100g DM]				
Rosa canina (*N*=3)*	(86.16±10.11)^{b}	(51.59±5.12)^{a}	40.12	(50.53±7.09)^{a}	40.24
Rosa subcanina (*N*=3)	(106.03±11.69)^{b}	(62.54±8.86)^{a}	41.15	(51.02±9.10)^{a}	52.08
Rosa corymbifera (*N*=3)	(75.70±15.37)^{b}	(51.86±7.83)^{a}	30.99	(46.32±4.17)^{a}	36.32
Rosa nitidula (*N*=3)	(65.02±8.89)^{b}	(49.39±6.48)^{a}	23.77	(44.57±3.15)^{a}	30.85
Rosa vosagiaca (*N*=3)	(93.59±35.32)^{b}	(65.29±22.22)^{a}	29.26	(59.30±22.27)^{a}	36.59
Cornus mas (*N*=10)	(6.58±1.13)^{b}	(5.90±1.12)^{b}	10.33	(0.77±0.25)^{a}	88.23

*The values are expressed as means of three or ten replications (±SD)
^{a,b,c} means within the same row followed by different letters are significantly different between groups (fresh, frozen, dried) by Tukey’s–HSD test, $p \leq 0.05$

Total sugar content

Total sugar content in the fruits of rose species was found to be in a range between 33.76 g/100 g DM in *Rosa subcanina* and 40.71 g/100 g DM in *Rosa vosagiaca* (Table 4).

A not significant increase of total sugar content was registered in frozen fruits: with 12.94 % in *Rosa vosagiaca* and 3.41 % in *Rosa corymbifera*. The frozen rose hips had a sugar total content between 34.96 g/100 g DM (*Rosa nitidula*) and 45.98 g/100 DM (*Rosa vosagiaca*). Drying process affected negatively and statistically significant ($p \leq 0.0001$) the total sugar content in rose hips, the registered values being in a range of 22.04 g/100 g DM–27.66 g/100 g DM (*Rosa subcanina* to *Rosa corymbifera*), which means a decreasing with 21.57 % (*Rosa nitidula*) to 34.69 % (*Rosa subcanina*).

Table 4. The influence of the storage methods on total sugar content (dry mass basis) in *Rosa* spp. L. and *Cornus mas* L. fruits

Species	Fresh fruits	Frozen fruits	Increase %	Dried fruits	Increase•/ Decrease•• %
	Total sugars [g/100g DM]				
Rosa canina (*N*=3)*	(37.48±0.80)^{b}	(40.02±1.40)^{b}	6.78	(24.97±0.83)^{a}	33.36••
Rosa subcanina (*N*=3)	(33.76±2.89)^{b}	(37.42±0.15)^{b}	10.84	(22.04±1.51)^{a}	34.69••
Rosa corymbifera (*N*=3)	(37.18±6.67)^{b}	(38.44±6.92)^{b}	3.41	(27.66±1.59)^{a}	25.57••
Rosa nitidula (*N*=3)	(32.66±0.64)^{b}	(34.96±1.82)^{b}	7.03	(25.61±0.62)^{a}	21.57••
Rosa vosagiaca (*N*=3)	(40.71±3.79)^{b}	(45.97±3.67)^{b}	12.94	(26.92±0.74)^{a}	33.85••
Cornus mas(*N*=10)	(48.41±4.76)^{a}	(66.00±2.97)^{b}	37.60	(63.22±5.90)^{b}	31.42•

*The values are expressed as means of three or ten replications (±SD)
^{a,b,c} means within the same row followed by different letters are significantly different between groups (fresh, frozen, dried) by Tukey's–HSD test, $p \leq 0.05$

Total sugar content in fresh cornelian cherry fruits was found to be in a mean of 48.41 g/100 g DM. Compared with the fresh fruits, the conserved cornelian cherry fruits are significantly richer in total sugar content, with 37.60 % in frozen fruits (66.00 g/100 g DM) and with 31.42 % in the dried fruits (63.22 g/100 g DM). No statistically significant differences between conserved fruit categories ($p \geq 0.05$).

Protein content

Rose hips are not very rich sources of proteins. The parameter varied also, in small limits, between analyzed species: 0.9 g /100 g DM–1.10 g/100 g DM (*Rosa corymbifera* to *Rosa nitidula*) (Table 5). Freezing process resulted in decreasing of protein content with 15.24 (*Rosa subcanina*) to 31.90 % (*Rosa nitidula*). Also, drying process affected negatively the protein level, with 21.33–46.89 % (*Rosa corymbifera* to *Rosa subcanina*). On the dry mass basis, the conserved rose hips had protein contents between 0.67 g/100 g DM (*Rosa corymbifera*) to a maximum of 0.93 g/100 g DM (*Rosa subcanina*), in frozen fruits, and between 0.58 g/100 g DM (*Rosa subcanina*) and 0.70 g/100 g DM (*Rosa nitidula*), in dried fruits.

Table 5. The influence of the storage methods on protein content (dry mass basis) in *Rosa* spp. L. and *Cornus mas* L. fruits

Species	Fresh fruits	Frozen fruits	Decrease %	Dried fruits	Decrease %
	Proteins [g/100g DM]				
Rosa canina (*N*=3)*	(1.00±0.15)^{b}	(0.80±0.12)^{a}	20.51	(0.64±0.07)^{a}	36.60
Rosa subcanina (*N*=3)	(1.10±0.10)^{b}	(0.93±0.08)^{a}	15.24	(0.58±0.10)^{a}	46.89
Rosa corymbifera (*N*=3)	(0.90±0.09)^{b}	(0.67±0.08)^{a}	23.72	(0.69±0.03)^{a}	21.33
Rosa nitidula (*N*=3)	(1.10±0.23)^{b}	(0.75±0.18)^{a}	31.90	(0.70±0.23)^{a}	36.63
Rosa vosagiaca (*N*=3)	(1.10±0.23)^{b}	(0.71±0.13)^{a}	28.55	(0.67±0.10)^{a}	32.72
Cornus mas (*N*=10)	(0.50±0.15)^{b}	(0.27±0.08)^{a}	46.32	(0.27±0.04)^{a}	45.12

*The values are expressed as means of three or ten replications (± SD)
^{a,b,c} means within the same row followed by different letters are significantly different between groups (fresh, frozen, dried) by Tukey’s–HSD test, $p \leq 0.05$

The *Cornus mas* analyzed genotypes had a lower protein content than rose hips. Fresh cornelian cherry fruits had a protein content of only 0.5 g/100 g DM. Both methods of conservation had the same effect on the protein level, resulting in 46.32 % lower level in frozen fruits and 45.12 % in dried fruits, when compared with the fresh fruits. The protein content was approximately 0.27 g/100 g DM in both categories of conserved fruits.

CONCLUSIONS

As a result of our study, the drying method has been found to decrease the ascorbic acid, carotene and total glucides contents in fruits, more than freezing method, but not dramatically. This is due, generally, to rapid decomposition, especially of biologically active compounds, at high temperature. By contrast, the storage at low temperature, by reducing the rate of oxidation, especially that of ascorbic acid to dehydroascorbic acid, resulted in a better preserving the nutritional quality of the frozen fruits. For this reason, vitamin C was used by many researchers as quality indicator (Erikson, 1997) in the studies regarding to nutritional changes in frozen foods during storage time.

For rose hips, freezing better preserved the ascorbic acid and total sugar content; both preservation methods had the same negative effect upon carotene and protein content, with no statistically significant differences between them.

In frozen and dried cornelian cherry fruits, the nutritional indicators were also decreased, with exception of total sugar content, which was found to be higher than in fresh fruits because of the polysaccharide hydrolysis during processing and storage; no statistically significant differences between the level of decomposition of ascorbic acid, total sugar and protein content in frozen and dried fruits were evidenced.

To conclude, this research showed, as novelty for rose hips and cornelian cherry fruits, that both traditional methods of fruits storage can be successfully used to obtain food with high biological value, with the note that freezing better preserved the bioactive compounds, such as vitamins.

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[1]NIRDBS– branch Institute of Biological Research Iasi, Department of Cell Biology and Microbiology, Iasi, Romania
[2]“Alexandru Ioan Cuza” University of Iasi, Faculty of Biology, Iasi, Romania
* craita2002@yahoo.com