Edible roses as novel food with healthy value

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Abstract

***Rosa* sp. is a very ancient genus belonging to *Rosaceae* family, including around 150-300 botanical species and thousands of hybrids and cultivars. The natural habitat of wild roses extends in Asia, Europe and North America. Roses were appreciated since periods of Egyptian, Persian, and Greek, due to their scent, aesthetic and decorative value. The traditional use of roses as food ingredients and medical products was reported since Roman time and european Middle Age. Nowadays it's common to include flowers petals in different sweet and savoury recipes. The ANTEA Project (UE Interreg-Alcotra IT-FR n.1139) aimed to extend the edible flowers consumption as functional food by the increase of the species number used for the supply chain. The creation of a high-quality flowers production has to take into account different flowering period in order to guarantee constant supply to consumers all year around.Therefore a further goal was focused on post-harvest storage and flowers transformation. 35 edible flowers were selected for their characteristics, and two of them belong to *Rosa* genus: *Rosa* × *centifolia* (hybrid, ongoing botanical classification) and *Rosa* 'Tango', also called Rose de Vence. The two rose plants were cultivated in greenhouse at Chambre d'Agriculture des Alpes-Maritimes (CREAM), Nice (France). Fresh freeze-dried petals and their infusion (freeze-dried flowers in boiling water for 8 min) were investigated in order to detect levels of healthful and antioxidant molecules, such as polyphenols and other antioxidant molecules. The highest total polyphenols content (TPC) and antioxidant activity were quantified in dried *Rosa* × *centifolia* petals. TPC was comparable in fresh petals and infusion of dried Rose de Vence petals, even if the latter had lower antioxidant activity.**

Keywords: secondary metabolites, antioxidant activity, ascorbic acid, Rose de Vence, *Rosa* × *centifolia*

INTRODUCTION

Rosa sp. is a very ancient genus of the *Rosaceae* family, that includes around 150-300 wild species and thousands of hybrids and cultivars (Mariotti et al., 2017). The origin of this genus is attributed to the plateaus of Central Asia (specifically Armenia and northern Persia), and distributed in four different places of diversity: Europe, America, West Asia, and the Orient (Damania, 2010).

Roses virtues were appreciated since the time of ancient civilisation, by the Egyptians, the Babylonians, the Greeks and the Romans. Thereafter, these flowers were recognized as symbol of beauty, seduction, love, celebration, and business opportunities (Damania, 2010).

Roses were used also for culinary purposes (Cunningham, 2015). The tradition to use them as edible flowers was maintained in different part of the world, and nowadays it's common to find rose petals in several sweet and savoury recipes. Numerous rose species, hybrids and cultivars are known as edible, and the most commonly used are: *R. damascena* (Sommano et al., 2018), *R. canina* (Hosni et al., 2010), *R. micrantha* (Guimarães et al., 2010), *R. rugosa* (Huang at al., 2017), *R. gallica* (Lee et al., 2018) and *R.* × *centifolia* (Banerjee and De, 2013).

In recent years, edible flowers gained popularity thanks to their nutritional properties,

health benefits and the low fat and energetic content (Pires et al., 2019; Rodrigues et al., 2017). In fact, different species can be a real source of antioxidant molecules (Lu et al., 2016; Pires et al., 2019), primary metabolites (Fernandes et al., 2017), vitamins C and E (Grzeszczuk et al., 2016; Fernandes et al., 2018), and minerals (Rop et al., 2012; Grzeszczuk et al., 2018). Roses are rich in flavonols (kaempferol and quercetin glucosides), flavanols (catechin, epicatechin, epigallocatechin gallate), and phenolic acids (gallic acid) (Zhang et al., 2014; Lu et al., 2016). Thanks to polyphenols and other healthy molecules, these flowers showed several biological activities as anticancer, diuretic, laxative, and antirheumatic; therefore, their consumption can be useful to prevent certain diseases (Lu et al., 2016; Fernandes et al., 2017).

In the framework of the INTERREG ALCOTRA Project on edible flowers (UE INTERREG ALCOTRA IT-FR ANTEA N◦1139, 2014-2020), two hybrids of roses, *R.* × *centifolia* and *Rosa* 'Tango', received a special interest, since they are closely tied to Provence-Alpes-Côte d'Azur (PACA) region, and therefore part of Provencal heritage. *R.* × *centifolia*, also called Rose de Mai, has been cultivated in the Grasse district, the capital of perfumery, since 16th century (Gilly, 1997). This rose is a shrub characterized by a single flowering in May, producing simple flowers with many pink petals (Figure 1B). *R.* × *centifolia* is widely cultivated due to its medicinal and ornamental properties, and its fragrance is sweet with light notes of honey (Jitendra et al., 2012). *Rosa* 'Tango', known as "Rose de Vence", was originally cultivated as cut flower, and later its powerful fragrance was appreciated for culinary purposes. Indeed, many Provencal confectioneries use this rose to produce crystallized petals, candies, jellies and syrups. *Rosa* 'Tango' is a re-flowering shrub, producing salmon orange flowers (Debener et al., 2003) (Figure 1C); this plant is able to withstand low temperature. *Rosa* 'Tango' has never been investigated so far by the nutritional point of view.

Figure 1. *Rosa* × *centifolia* plants in open field (A); *Rosa* × *centifolia* flowers (B); *Rosa* 'Tango' flowers (C); *Rosa* 'Tango' freeze-dried petals (D); *Rosa* 'Tango' infusion preparation (E).

In this work, fresh, freeze-dried flowers and rose infusion were analyzed to determine their nutritional characteristics: total polyphenols, ascorbic acid and soluble sugars content, as well as petals antioxidant activity were detected. The results suggest the best way to consume *R.* × *centifolia* and *Rosa* 'Tango' flowers.

MATERIALS AND METHODS

Plant material and cultivation

R. × *centifolia* of Grasse, PACA (FR) is a hybrid originated by crossbreeding different species, including *R. damascena, R. gallica* and *R. moschata* (personal communication). *Rosa* 'Tango' is a hybrid of tea-rose created by the French grower George Delbard in 1978 by crossing [(Belle Rouge × (Gloire de Rome × Gratitude)) × ((Dr Schweitzer × Tropicana) × (Ena Harkness × Québec))] (Debener et al., 2003). *R.* × *centifolia* plants were originated by cuttings provided by producers of Grasse (FR), while cuttings of *Rosa* 'Tango' were taken from

producers in Vence (Provence - FR). The two roses were cultivated in open field and in greenhouses at the producers and the Chambre d'Agriculture des Alpes-Maritimes (CREAM) (43.668318N, 7.204194E) (Figure 1).

Sample and infusion preparation

The flowers of *Rosa* × *centifolia* were collected in May 2019; while the roses of the 'Tango' hybrids were harvested between May and September 2018. For both hybrids, the petals, the only edible part of flowers, were detached, weighted and frozen in paper bags at -80°C. Subsequently, petals were vacuum freeze-dried at -50°C (Labconco, Kansas City, USA) for 48 h. Paper bags with freeze-dried rose petals were stored in plastic bags with hygroscopic salt silica gel (1-3 mm) (VWR Chemicals) until analysis.

Homogeneous fresh samples were obtained by grinding rose petals in pre-chilled mortar and pestle. For each analysis, 200 mg of sample were used. Similarly, freeze-dried rose petals were reduced to a fine powder at room temperature, and 50 mg of sample were used for each analysis.

For infusions preparation, 50 mL of boiling distilled water was added to 250 mg of unground freeze-dried petals, contained in common tea-bags (Figure 1E). Petals and water were allowed to stand at room temperature for 8 min. Once cooled, the infusions were used for further analysis.

Biochemical analyses

Radical scavenging activity (DPPH assay) and total polyphenols, flavonoid and anthocyanins content were performed as described in Marchioni et al. (2019). Total and reduced ascorbic acid were quantified as reported in Najar et al. (2019), as well as total soluble sugars. Infusions were analyzed without undergoing further extraction procedures.

For each biochemical determination, three biological replicas were performed.

RESULTS AND DISCUSSION

Rose petals are commonly used as edible flowers, thanks to their sweet and aromatic flavour (Mlcek and Rop, 2011). They are very versatile and appreciated as fresh or dried. In the latter case, freeze-drying is the best method for removing water from petals. The final products are of the highest quality compared to those obtained with other food drying methods. The freeze-drying treatment can protect their shape and physical-chemical characteristics (Ratti, 2001; Serrano-Díaz et al., 2013).

In this work, *R.* × *centifolia* freeze-dried petals showed the highest content of polyphenols (189.38 mg g^{-1} DW), flavonoids (20.11 mg g^{-1} DW) and anthocyanins (2.12 mg g^{-1} DW) and the lowest amount were detected in the *R.* 'Tango' fresh petals (Table 1).

Table 1. Secondary metabolites, radical scavenging activity (DPPH), ascorbic acid and total soluble sugars content of *Rosa* 'Tango' and *R.* × *centifolia* petals (fresh – only *Rosa* 'Tango', freeze-dried and infusion). Data are presented as means ± SE (*n*=3).

Parameters	*Rosa* 'Tango'			*Rosa* × *centifolia*	
	Fresh (mg g^{-1} FW)	Freeze-dried (mg g^{-1} DW)	Infusion (mg 100 mL^{-1})	Freeze-dried (mg g^{-1} DW)	Infusion (mg 100 mL^{-1})
Polyphenols (GAEq)	12.14±0.21	60.09±3.70	13.65±0.15	189.38±7.93	24.25±0.22
Flavonoid (CEq)	2.57±0.06	10.76±0.51	1.86±0.06	20.11±1.05	3.75±0.11
Anthocyanins (MEq)	0.19±0.01	0.92±0.09	0.07±0.00	2.12±0.12	0.18±0.01
DPPH (IC_{50})	0.41±0.01[a]	0.16±0.01[b]	0.05±0.00[c]	0.04±0.00[b]	0.02±0.00[c]
Reduced ascorbic acid	0.02±0.00	0.15±0.01	0.34±0.01	0.43±0.01	0.79±0.01
Total ascorbic acid	0.13±0.00	0.28±0.01	0.43±0.02	0.45±0.01	0.87±0.02
Total soluble sugars	72.51±5.76	216.96±2.56	117.25±0.88	201.4±8.49	97.57±0.78

[a]mg FW mL^{-1} DPPH; [b]mg DW mL^{-1} DPPH; [c]mL infusion mL^{-1} DPPH.

GAE – gallic acid equivalents; CE – catechin equivalents; ME – malvin equivalents.

Our results on *R.* × *centifolia* freeze-dried flowers were quite similar to those already published in air-dried *R.* × *centifolia* petals, collected in a local market in China (Zheng et al., 2018). Freeze-dried and fresh petals of *Rosa* 'Tango' exhibited quite low amounts of total polyphenols and flavonoids, in comparison with other different rose species (Zheng et al., 2018). However, several polyphenols extraction methods were performed in previous rose reports, different from that used in this work. Thus, several literature results were tricky to compare with our data.

Several antioxidant molecules have radical scavenging activity (Cavaiuolo et al., 2013), as demonstrated in *R. hybrida* flowers, in which is highly correlated with total polyphenols, total flavonoids, and ascorbic acid (Hou et al., 2014). In our study, IC_{50} values were lower in *R.* × *centifolia* freeze-dried flowers and less activity was observed in *Rosa* 'Tango' freeze-dried flowers and *Rosa* 'Tango' fresh flowers.

Neither *Rosa* 'Tango' nor *R.* × *centifolia* can be considered a good source of ascorbic acid (or vitamin C) since other roses, such as *R. micrantha* (2.95 mg g^{-1} DW) (Guimarães et al., 2010) and *R. hybrida* 'Carola' and 'Iceberg' (around 0.32 and 0.23 mg g^{-1} FW, respectively) (Hou et al., 2014), were characterized by higher amount of this vitamin.

As regards primary metabolites, roses are rich in carbohydrates and different soluble sugars were quantified in these flowers (Guimarães et al., 2010; Ichimura et al., 1997). Nevertheless, both *Rosa* 'Tango' and *R.* × *centifolia* were characterized by low total soluble sugars (TSS) compared to other species studied before. Indeed, fresh petals of *R. hybrida* 'Grandgala' and 'First Red' contained around 2-fold TSS than *Rosa* 'Tango' fresh flowers (Naveen et al., 2007). Similarly, more TSS were quantified in dried petals of *R. damascena* compared to dried *Rosa* 'Tango' and *R.* × *centifolia* flowers (Vijayanchali, 2017). On the other hand, TSS ranged between 0.023 and 0.036 mg g^{-1} FW in 13 cultivars of Brazilian roses (Prata et al., 2017), far below 72.51 mg g^{-1} FW detected in *Rosa* 'Tango' petals. This is probably due to different extraction solvent, water instead of ethanol (Prata et al., 2017).

Rose petals are appreciated as infusion in different part of the world, especially in Asia, and the commercially available species mainly include *R. damascena*, *R.* × *centifolia*, *R. rugosa*, and *R. rugosa* f. plena (Qin et al., 2018).

In this work, *R.* × *centifolia* infusion contained more healthy molecules than *Rosa* 'Tango' infusion, in agreement with the results obtained with freeze-dried petals. The TPC in both rose infusions were in line with the results obtained by Vinokur et al. (2006), who quantified TPC in infusions of 12 different rose cultivars. Similarly, the total anthocyanins content observed in our work was comparable to that of Vinokur et al. (2006). However, infusions of three different species of Chinese rose (Kuishui Rose, Pinying Rose, and Jinbian Rose) contained lower TPC than those quantified in this report (Qin et al., 2018).

Noteworthy, *R.* × *centifolia* and *Rosa* 'Tango' infusions were characterized by a high radical scavenging activity, and the heat of the water did not completely compromise the total content of ascorbic acid. Moreover, a single cup of rose (around 250 mL) infusion can contain comparable quantities of TSS to 1 g of freeze-dried *R.* × *centifolia* and *Rosa* 'Tango' petals (around 1.80 g and 5.70 g of fresh flowers, respectively).

CONCLUSIONS

In this work, petals of two Provence roses were analyzed for their antioxidant properties. The results showed that total polyphenols and ascorbic acid content were higher in *R.* × *centifolia* than *Rosa* 'Tango' freeze-dried flowers. The latter contained slightly higher total soluble sugars. The two rose infusions were characterized by a high radical scavenging activity. Comparing with data reported in literature, the two Provence roses can be a good source of antioxidant molecules both freeze-dried and in infusion preparation, providing nutritional and healthy values.

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