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 varieties. 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 find flowers petals in different sweet and savoury recipes.**

The ANTEA Project (UE Interreg-Alcotra IT-FR n.1139) aims to extend the use of edible flowers as functional food and to enlarge the number of the species used for their supply chain. The objective of the projyect is the creation of a high-quality flowers production involving species characterised by different flowering period in order to guarantee constant supply to consumers all year around. In addition, the project focus on post-harvest storage and flowers transformation. To date, 35 edible flowers are under evaluation by CREA of Sanremo, two of which belonging to *Rosa* genus: *Rosa* x *centifolia* (hybrid, ongoing botanical classification) and *Rosa* 'Tango', also called Rose de Vence. Plants are cultivated in greenhouse at Chambre d'Agriculture des Alpes-Maritimes (CREAM), Nice. Fresh freeze-dried petals and their infusion (freeze-dried flowers in boiling water for 8 minutes) are 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* x *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* x *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 varieties (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 et al., 2010).

Roses virtues were appreciated since the time of ancient civilisation, by the Egyptians, the Babylonians, the Greeks and the Romans. Thereafter, these flowers became symbol of beauty, seduction, love, celebration, war, politics, and business opportunities (Damania et al., 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.

Until now, numerous rose species, hybrids and varieties are known as edible, and the most common 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). In particular, 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 hybrid 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.* x *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 characterised 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.

In this work, fresh, freeze-dried flowers and rose infusion were analysed to determine their nutritional characteristics: total polyphenols, ascorbic acid and soluble sugars content, as well as petals antioxidant activity were detected. The results can 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, only edible part of flowers, were detached, weighted and frozen for at least one week 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.

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).

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 analysed 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 & Rop, 2011). They are very versatile and appreciated fresh or dried. In the latter case, freeze-drying is the best method of 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 et al., 2001; Serrano-Díaz et al., 2013).

In this work, *R.* × *centifolia* freeze-dried petals showed the highest content of polyphenols (189.38 mg/g DW), flavonoids (20.11 mg/g DW) and anthocyanins (2.12 mg/g DW) (Table 1), 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). Abbreviation: GAE – gallic acid equivalents; CE – ± catechin equivalents; ME – malvin equivalents.

Parameters	***ROSA* 'TANGO'**			***ROSA* × *CENTIFOLIA***	
	Fresh (mg/g FW)	**Freeze-dried (mg/g DW)**	**Infusion (mg/100 ml)**	**Freeze-dried (mg/g DW)**	**Infusion (mg/100 ml)**
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 DPPH; [b]mg DW/ml DPPH; [c]ml infusion/ml DPPH

To the best of our knowledge, previous works were performed using different rose polyphenols extraction, making it difficult to compare our data with those found in the literature. However, our results on *R.* × *centifolia* freeze-dried flowers are quite similar to those already published in air-dried *R.* × *centifolia* petals, collected in a local market in China (Zheng et al. 2018). The small discrepancy detected is certainly due to genetic differences between the two roses. On the other hand, freeze-dried and fresh petals of *Rosa* 'Tango' exhibited quite low amounts of total polyphenols and flavonoids, in comparison with other different rose species (Yan & Shin, 2017; Zheng et al., 2018).

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

Total polyphenols content (TPC) is proportional to the antioxidant activity. Indeed, IC_{50} values were in *R.* × *centifolia* freeze-dried flowers < *Rosa* 'Tango' freeze-dried flowers < *Rosa* 'Tango' fresh flowers. Several antioxidant molecules have radical scavenging activity (Cavaiuolo et al., 2013), and, in *R. hybrida* flowers, this parameter is highly correlated with total polyphenols, total flavonoids, and ascorbic acid (Hou et al., 2014).

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., 2014). Nevertheless, both *Rosa* 'Tango' and *R.* ×*x centifolia* are characterised by less 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 (Kumar et al., 2007). Similarly, more TSS are quantified in dried petals of *R. damascena* compared to dried *Rosa* 'Tango' and *R.* × *centifolia* flowers (Vijayanchali et al., 2017). On the other hand, TSS ranged between 0.023-0.036 mg/g FW in thirteen cultivars of Brazilian roses (Prata et al., 2017), far below 72.51 mg/g 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., 2016). In this work, *R.* × *centifolia* infusion contains more healthy molecules than *Rosa* 'Tango' infusion, in agreement with the results obtained with freeze-dried petals. The (TPC) in *R.* × *centifolia* and *Rosa* 'Tango' infusions were in line with the results obtained by Vinokur et al. (2006), who quantified the same secondary metabolites in infusions of twelve different rose cultivars. Between the two studies, also the total anthocyanins content is comparable, (Vinokur et al. 2006). On the other hand, TPC were higher in our infusion compared to the ones obtained with three different species of Chinese rose (Kuishui Rose, Pinying Rose, and Jinbian Rose) infusions (Qin et al., 2016).

Noteworthy, *R.* × *centifolia* and *Rosa* 'Tango' infusions are characterised 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 analysed by the nutritional point of view. The results showed that total polyphenols and ascorbic acid content is higher in *R.* × *centifolia* than *Rosa* 'Tango' freeze-dried flowers. The latter contained slightly higher total soluble sugars. The two rose infusions were characterised 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.

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