DOGROSES (*ROSA* SECT. *CANINAE* L.), OLD MEDICINAL PLANTS WITH A LARGE POTENTIAL – A REVIEW

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Contents

Summary

Dogroses, i.e. species belonging to *Rosa* sect. *Caninae* L., grow wild along roadsides and in disturbed areas in temperate regions, and have also been cultivated in some countries to a lesser extent. However, the newly acquired interest in food products with health-promoting substances may lead to new plantations. Rosehips from dogroses have been shown to contain very high levels of antioxidant compounds, mainly polyphenols, but also carotenoids and the vitamins B, C and E. Several different studies have shown rosehip extract to have anti-inflammatory, antinociceptive, anti-diabetic and anti-mutagenic effects. It has also been shown to inhibit certain cancer cell proliferation *in vitro*. The most well-performed studies so far concern the positive effect on patients with osteoarthritis, as well as effects on various stomach problems. Rose hip extract has also been shown to have an inhibitory effect on body weight gain, and to reduce the glucose level in the blood stream making it useful as a treatment against obesity. The

seeds contain high levels of unsaturated fatty acids, which can be used for skin treatment and cosmetics. The amount of these bioactive compounds varies with genotype and environment. The dogroses can be seed-propagated, but as the germination is slow, cuttings are preferred. The rosehips are mainly harvested by hand, and should be picked when almost ripe, and then dried or frozen as soon as possible, to ensure high contents of bioactive compounds. Presently, production of dogrose rosehips is increasing due to the big interest from health-conscious consumers.

1. Introduction

The well-known genus *Rosa* in the family Rosaceae contains numerous species of commercial interest. Several wild rose species like *Rosa moschata, R. wichurana*, *R. multiflora*, *R. damascena*, *R. gallica*, *R. chinensis, R. gigantea*, and *R. foetida* have contributed to the highly appreciated and economically important ornamental rose cultivars, and in the case of *R. damascena* also to the rose oil industry.

Other rose species have been less noted by the rose-growing industry but some have the potential to become very important due to their fruits, the rosehips. Commercial rosehip production involves several different rose species. One important group is the dogroses, all of which belong to the section *Caninae.* These are long-lived woody perennials, growing in woodland margins and disturbed habitats such as roadsides and open pastures. Dogroses are sometimes planted as ornamentals, especially in public areas where they are appreciated for their rustic appearance and hardiness. Several dogrose species have also been used as rootstocks for the budding of ornamental roses, but other rootstocks with superior characteristics are now being used to an increasing extent. In the middle ages, dogroses were however cultivated, especially at monasteries, for use as valuable medicinal plants. Almost all parts of the plants were used: rosehips, seeds, petals, leaves and roots. During the last two decades, a renewed interest in the dogrose species have emerged since modern science have shown that rosehips contain valuable compounds that can be used as functional food or nutraceuticals.

2. Taxonomy

Rose taxonomy is quite complicated and there have been several attempts to improve the classification of roses through the years. For lack of a commonly accepted alternative, most people still use the system of Rehder (1940), updated by Wissemann (2003), which comprises four subgenera: *Hulthemia* (1 species), *Hesperhodos* (two species), *Plathyrhodon* (one species) and *Rosa* (approx. 180 species). Subgenus *Rosa* is subdivided into 10 different sections, and the largest of these sections is sect. *Caninae*, dogroses, with approx. 50 species. The other sections are *Pimpinellifoliae* (15 species), *Rosa* (only one proper species but several hybrid taxa have been given species rank), *Carolinae* (possibly five species), *Cinnamomeae* (about 80 species), *Synstylae* (about 25 species), *Indicae* (three species), *Banksianae* (possibly two species*), Laevigatae* (one species) and *Bracteatae* (one or two species).

Within the genus *Rosa*, section *Caninae* has proved to be the most difficult group. At the beginning of the last century, the name-giving was at its peak when the Swedish rhodologist Almqvist (1919) described more than 350 dogrose species on one island alone in the Stockholm archipelago! Today, there is a more restricted view on what entity is entitled species rank, and the number of recognized dogrose species presently hoovers around 50 (Wissemann 2003). Up to six subsections are generally recognized; subsect. *Trachyphyllae* with *R. jundzillii* as the only species, subsect. *Rubrifoliae* with *R. glauca* (syn. *R. rubrifolia*) as the only species, subsect. *Vestitae* with, e.g., *R. mollis*, *R. pseudoscabriuscula, R. sherardii*, *R. tomentosa* and *R. villosa* (syn. *R. pomifera*), subsect. *Rubigineae* with, e.g., *R. agrestis*, *R. inodora*, *R. micrantha.,* and *R. rubiginosa*, subsect. *Tomentellae* with *R. tomentella* and *R. abietina*, and subsect. *Caninae* with, e.g., *R. canina*, *R. corymbifera*, *R. dumalis*, *R. montana*, *R. stylosa, R. subcanina* and *R. subcollina* (Wissemann 2003).

Traditionally, dogrose species have been defined according to morphological characters like leaflet shape, hip shape, length of pedicel, presence or absence of glandular hairs, shape of prickles, shape of style head orifice, leaf pubescence, and plant shape. Although some discontinuities are noted, these characters have often been insufficient for unambiguous classification of plant material, even when this material has been grown in comparative garden trials (Nybom et al. 1996, Olsson et al. 2000, De Cock et al. 2008).

Figure 1. *Rosa rubiginosa* in full bloom

In recent years, morphology-based information has often been complemented with DNA-based data for plant classification studies. In dogroses, many taxa have, however, turned out to be even more difficult to distinguish when analysed with DNA markers compared to when analysed with morphological characters. Samples from closely related species (belonging to the same subsection) have often turned out to overlap completely when analysed with DNA markers like RAPD and AFLP (Olsson et al. 2000, Atienza et al. 2005, de Cock et al. 2008, Koopman et al. 2008). By contrast, the same studies have usually reported some level of discontinuity between at least the three major subsections: *Vestitae*, *Rubigineae* and *Caninae* suggesting that these constitute biologically valid and identifiable taxa.

In this report, we present a substantial amount of the research so far published on rose species suitable for rosehip production, with a major emphasis on the dogrose species.

3. Cytology and Reproduction

In the genus *Rosa*, the basic chromosome number x = 7. Diploid rose species thus have two sets of chromosomes, 2n = 14. In meiosis, these 14 chromosomes pair up to form seven bivalents as expected, resulting in regular biparental inheritance. Many rose species as well as almost all ornamental cultivars are instead tetraploid, with 2n = 28. Also these have a regular bivalent formation.

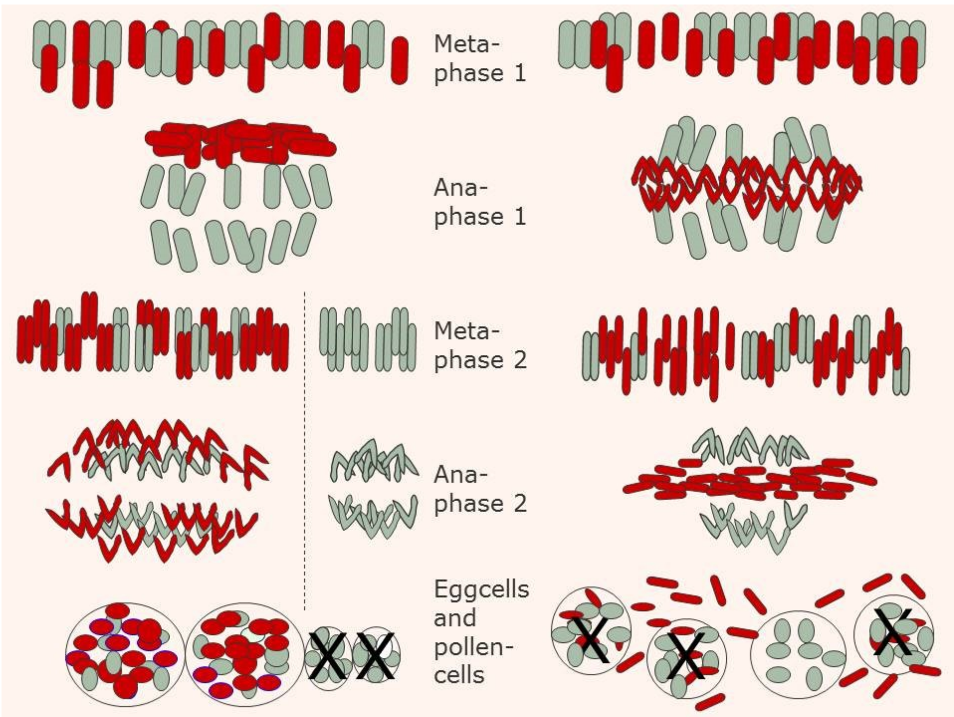

Figure 2. *Canina* meiosis. In the female meiosis, 14 chromosomes form 7 bivalents whereas the remaining chromosomes occur as univalents and gather towards one side of the cell. The bivalent chromosomes pair and recombine, and after the separation and second division, two viable cells are formed with 7 chromosomes from the bivalent formation and all the univalents, and two inviable cells with only the 7 chromosomes from the bivalent formation. At the male side, 7 bivalents are again formed, but this time the univalents start to separate into chromatids already in the first metaphase. After the second division, most of the univalents are lost, or occur as chromatids or chromosome parts in some of the pollen cells. Viable pollen cells contain only the 7 chromosomes from the bivalent formation; pollen viability in the section *Caninae* is only 20–35%.

There is, however, one notable exception in the genus. Thus, all dogroses (sect. *Caninae*) are characterized by the peculiar *canina* meiosis described over 80 years ago (Täckholm, 1922) and verified in several, more recent publications (e.g. Lim et al., 2005). The dogroses are usually pentaploid although some tetraploids and hexaploids also occur. Regardless of ploidy level, only seven bivalents are formed in the first meiotic division. The remaining chromosomes occur exclusively as univalents. These univalents are not included in viable pollen grains, which contain only the seven divided bivalent chromosomes. In contrast, all the univalents are transmitted to one of the daughter cells in the female meiosis, and are finally included in the viable egg cells, which therefore contain 21, 28 or 35 chromosomes, depending on the ploidy level. The resulting seedlings obtain the full chromosome number but only 15–25% of these chromosomes are inherited from the pollen parent, whereas the remainder are obtained from the seed parent. This means that the offspring usually is much more similar to the maternal parent (matroclinal inheritance) than to the paternal parent. In addition, results from morphological evaluation of spontaneous or experimentally derived dogrose progenies has led some scientists, e.g., Gustafsson (1937, 1944) and Kroon and Zeilinga (1974) to suggest an apomictic seed production, i.e. seeds being produced without prior fertiliztion of the egg cell. Recently, up to 5 or 10% apomictic seed set has also been demonstrated with DNA markers in som dogrose species (Werlemark et al., 1999; Werlemark, 2000; Werlemark and Nybom, 2001; Nybom et al., 2004a, 2006).

Diploid rose species are usually selfsterile which means that they have to be crosspollinated in order to set seed. By contrast, polyploid rose species, including the dogroses, are usually self-fertile and can therefore set seed after selfing. Breeding behaviour affects the amount and partitioning of genetic variation in wild populations, and in the offspring of plants used in breeding programmes.

4. Genetics and Plant Breeding

Presently, precise information on character inheritance has been developed mostly for ornamental rose cultivars in traits that have little or no relevance for rosehip production, like flower morphology, colour and fragrance, moss character, dwarf phenotype, stem prickles, petiole prickles, foliage glossiness and recurrent blooming (Debener, 2003; Byrne 2009). Although highly desirable in ornamentals, the recessively inherited recurrent blooming trait is a serious draw-back in roses grown for hip production, especially in machine-harvested orchards since repeated harvesting is required. Lack of prickles on the stems would improve manual orchard work but could also render the plants more vulnerable to grazing animals in orchards with inadequate fencing. When prickles are present, their number and size are quantitatively inherited (Lal et al., 1082).

The climbing growth type has been reported to be dominant over the non-climbing growth type in ornamental roses (Morey, 1954). Interestingly, the arching growth type in dogroses has also been reported to be dominant over the more desirable erect (and non-climbing) growth type (Wissemann et al., 2006). Other growth type-related traits studied in ornamental roses like length of the flowering stems and plant height, as well as branch number and plant spread, are under polygenic control with a high heritability (Lal et al., 1982). Similarly, most of the vigour-related traits so far investigated in connection with ornamental rose breeding, appear to be under polygenic control (Byrne 2009).

Analyses of resistance against fungal diseases in ornamental roses and some diploid wild species, have demonstrated both polygenically controlled, horizontal resistance and vertical, race-specific resistance conferred by major genes, e.g., *Rdr1* and *Rbs* providing resistance against blackspot, *Marssonina rosae* (Kaufmann et al., 2003; Yan et al., 2005b), and *Rpp1* and *Rpm* providing resistance against powdery mildew (Linde et al., 2004; Zhang, 2003). In dogroses, both blackspot and powdery mildew instead appear to be under polygenic control since at least some symptoms can be found on all investigated species so far (Carlson-Nilsson and Uggla, 2005; Uggla and Carlson-Nilsson, 2005; Schwer et al., 2007). Similarly, rust and *Sphaceloma*-leafspot occur in all dogrose species evaluated although at variable levels (Schwer et al., 2007). Boerema (1963) reports that some dogrose species like *R. canina, R. tomentosa, R. villosa* and *R. rubiginosa* are susceptible to *Septoria*-leafspot, whereas other species lack symptoms altogether. In a Swedish study, *R. rubiginosa* had no symptoms although other species in the same field were heavily infested, suggesting a genetically controlled, perhaps monogenic resistance (Schwer et al., 2007).

Figure 3. The fungal disease blackspot (*Diplocarpon rosae* perfect stage, or *Marssonina rosae* imperfect stage)

Figure 4. The fungal disease leafspot (*Sphaceloma rosarum*) also known as anthracnose

So far, little if any directed plant breeding has been undertaken for increasing contents of bioactive compounds in rosehips. Considerable levels of inter- and intraspecific variation has, however, been reported for various compounds like ascorbic acid, lycopene, minerals, phenolic compounds and total antioxidant activity (Celik et al. 2009; Günes 2010; Turkben et al. 2010a). These results suggest that there is a considerable potential for developing new rose hip cultivars with more desirable chemical contents.

5. Health-Related Properties

Nowadays, people are becoming increasingly concerned about issues related to food and health. Fruit and berries are appreciated for their often high contents of health-promoting compounds. In this context, dogroses have been regarded as important medicinal plants since the middle ages. Rosehips, as well as petals, leaves and seeds, have been used for all sorts of concoctions and tonics to treat a wide range of ailments. Therapeutic activities have thus been described against the common cold, gastro-intestinal disorders and gastric ulcers, and different kinds of inflammatory disorders, e.g., arthritis. Uses as a laxative and a diuretic have also been reported.

The mechanisms responsible for possible medicinal effects of rosehips have, for the most part, not yet been discovered. Chemical analyses of bioactive compounds have been undertaken as a step in revealing health-promoting activities. Rosehips from dogroses have thus been shown to contain very high levels of ascorbic acid, and to have the highest percentage of total antioxidants among a large set of different fruit and berry crops (Halvorsen et al. 2002). Lycopene levels equal those found in tomatoes (Böhm et al. 2003), and there is also a high level of folate (vitamin B) (Strålsjö et al. 2003). Rosehip seeds are very rich in unsaturated fatty acids (Szentmihályi et al. 2002). Many medicinal properties have thus been reported for rosehip extracts, e.g. growth inhibition of certain cancer cells (Olsson et al. 2004), decreased activity of reactive oxygen species (ROS) in rat colons (Håkansson et al. 2006), and an anti-inflammatory response when consumed by patients with osteoarthritis (Winther et al. 2005).

6. Chemical Contents

Unfortunately, it is almost impossible to compare different reports on the bioactive compounds in dogroses. To begin with, very few of the authors of these studies are aware of the taxonomic complexity within section *Caninae*. Instead, the studied rosehips are often said to have been collected from *R. canina* even though they may actually have been collected from a different species within the section, or even from another section. Sometimes the species is not mentioned at all; perhaps the extraction was made on material bought in another country or picked in the backyard. Also, several studies show that there is variation in concentration of bioactive compounds between genotypes within one species, even if they grow in the same place (Uggla et al. 2003). The composition of bioactive compounds is also affected by the ripening stage of the rosehips at harvest (Guimaraes et al. 2010). Similarly, blooming stage of harvested *R. damascena* flowers affect the amount and quality of the industrial rose oil obtained (Baydar & Baydar 2004).

The chemical contents of rosehips are also dependent on various environmental factors (Demir & Özcan 2000, Celik et al. 2009, Ghazghazi et al. 2010). Differences in composition between years depending upon precipitation, temperatures, insolation etc have thus been reported (Kovacs & Toth 2000, Strålsjö et al. 2003, Uggla et al. 2003, Kähkönen et al. 2001, Ross & Kasum 2002). The latitude of the location also appears to affect the biochemical composition (Keles 2007).

Similarly, the amount of polyphenols in the leaves is affected by, e.g., gall insect infestations (Coruh & Ercisli 2010). Chemical contents are also dependent upon the post-harvest procedures, e.g, on how long time it takes before the rosehips are frozen or dried. Traditionally, rosehips are put out in the sun to dry, which can take several days during which the contents may deteriorate. Finally, extraction methods are also important for measuring of chemical contents

All papers cited in our study have been published in peer-reviewed journals. Still, reviewers have not always noticed if the authors mentioned whether they studied dry or fresh material; concentrations are of course higher per gram in dry material compared to in fresh material. The authors also report concentrations in different ways, e.g. g/kg FW, µg/g DW, mg GAE/g DW, mmol/g FW etc, making it difficult to compare the different results.

Also, some authors do not mention whether they have used whole rosehips with seeds or rosehips without seed. Dogrose-derived rosehips contain 25–40 seeds/hip, which is approximately ¼ of the total weight of the hip. These seeds contain over 77% polyunsaturated fatty acids (PUFA), which are very susceptible to chemical reactions and can cause rapid deterioration of other compounds (Concha et al. 2006).

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Glossary

AFLP :	Amplified fragment length polymorphism
α-tocopherol :	Vitamin E
All-*trans*-retinoic acid :	ATRA or tretinoin. A natural pre-cursor of vitamin A used to treat different skin problems and in cosmetics, found in rosehip seeds
Anaerobic conditions :	Without oxygen
Antinociceptive :	Reducing sensitivity to painful stimuli

Antioxidant :	A molecule capable of inhibiting oxidation of other molecules and prevent ROS damage by scavenging the free radicals.
Apomixis :	The ability to set seed without prior fertiization, offspring becomes identical to mother plant
Ascorbic acid :	Vitamin C
Carotenoids :	Antioxidants that can be divided into two groups, xanthophylls and carotenes. Within the carotenes there are α-carotene, β-carotene (precursor to vitamin A) and lycopene.
Chemotaxis :	Movement of cells or organisms along a chemical concentration gradient either towards or away from the simulus.
COX :	Cyclooxygenase enzymes responsible for inflammation and pain.
DW :	Dry weight
Ellagic acid :	A polyphenolic tannin compound, claimed to have beneficial effects against cancer and other medicinal problems. High levels have been found in raspberries, strawberries and rosehips
Flavonoids :	Type of polyphenols, consisting of six major subclasses: flavones, flavonols, flavanones, cathechins, anthocyanidins and isoflavones. The flavonoids act as antioxidants and inhibits the oxidation of low density lipoproteins and prevent aggregation of platelets.
Folate :	Vitamin B_9
Functional food :	A food where a new ingredient/s has been added or where an existing ingredient has been increased, and the new product has a new function, often related to health promotion or disease prevention.
FW :	Fresh weight
GAE :	Gallic acid equivalent
Gastrointestinal tract :	The stomach and intestine
Horizontal resistance :	Many genes are involved in the resistance, usually provides unspecific, durable resistance
Interspecific variation :	Variation between the species
Intraspecific variation :	Variation within the species
***In vitro* :**	The biological experiment is conducted outside the organism
***In vivo* :**	The biological experiment is conducted inside the living organism
Linoleic acid :	Omega-6, an essential fatty acid in rosehip seeds
Linolenic acid :	Omega-3, an essential fatty acid in rosehip seeds
Lipogenic :	Producing, forming or caused by fat
Matroclinal inheritance :	The genetic material in the offspring is inherited mainly from the seed parent

Meiosis : Chromosome division, takes place immediately before the formation of egg cells and pollen cells, usually results in a 50% reduction of the chromosome number.

Nutraceuticals : "a product isolated or purified from foods that is generally sold in medicinal forms not usually associated with food. A nutraceutical is demonstrated to have a physiological benefit or provide protection against chronic disease" Health Canada definition. The products may range from isolated nutrients, dietary supplements and specific diets to herbal products and processed foods.

Osteoarthritis : A progressive disorder of the joints caused by gradual loss of cartilage. One of the most common causes of disability especially in people over 50.

Ploidy level : Refers to the number of chromosomes. In the genus *Rosa*, the basic chromosome number is 7, diploid species have 14 chromosomes, triploid have 21, tetraploid have 28, pentaploid have 35 and hexaploid have 42.

Pro-oxidant : Can induce oxidative stress either through creating ROS or inhabiting antioxidant systems

RAPD : Random amplified polymorphic DNA

RNS : Reactive nitrogen species

ROS : Reactive oxidative species, forms naturally in the body as a byproduct of normal metabolism so called free radicals. However, in stress situations e.g. sickness, smoking, radiation, ROS levels can increase to high levels and cause significant damage to cell structures.

Selfing : Self-pollination, generally produces very homogenous offspring

Supercritical CO_2 : Fluid state of CO_2 used as solvent with low toxicity and environmental impact

Unsaturated fatty acids : A fatty acid with at least one double bond within the fatty acid chain and thus an elimination of one hydrogen atom, whereas saturated fatty acids do not have any double or triple bonds. An unsaturated fatty acid contains less energy (calories) than a saturated fatty acid. Diets high in polyunsaturated fatty acids and low in saturated fatty acids have been correlated with low serum cholesterol levels in some studies.

Vertical resistance : A single gene is responsible for the resistance, often provides race-specific resistance, prone to 'resistanc breaking'

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