Chapter

Rose Hip as a Nutraceutical

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Abstract

From ancient times, rose hip has been used as food source and as part of herbal remedies. Modern research has confirmed that rose hip, especially when containing seeds and shells, reduces pain and improves daily activity in animal models and in patients with osteoarthritis. The effect size on pain is comparable to that observed with nonsteroidal anti-inflammatory agents and superior to that obtained with paracetamol. For example, treatment with a subspecies of *Rosa canina* (Lito) resulted in 50% reduction in intake of pain killers. There are also strong indications that conditions such as rheumatoid arthritis, aging skin, and wrinkles benefit from treatment with rose hip. Cardiovascular diseases, especially where hyperlipidemia plays a major role, can be treated with rose hip, since a modest reduction of blood cholesterol levels as well as kidney and liver protection has been reported with the treatment. Variation in efficacy and amount of active ingredients in the different species, as well as with different ways of production, should be recognized. Rose hip can be collected from nature. It takes 5–7 *Rosa canina* berries to produce the daily dose of 5 gram of mixed shell-seed powder.

Keywords: Rosa canina, rose hip, seeds, shells, anti-inflammatory, antioxidant, vitamin C, collagen

1. Introduction

Rose hip is the pseudo-fruit of the wild rose (genus *Rosa* L.), the ancestor of the cultivated rose that is one of the most important flowers of the floricultural industry [1]. The genus *Rosa* includes over 100 different species that are found in many parts of the world, including North and South America, Europe, Asia, the Middle East [2], as well as in some parts of Africa [3, 4]. While most species originate from Asia, some are native to Europe, northwest Africa, and North America [5]. Wild roses are widespread in nature and are generally hardy plants capable of growing in many different environments. Some species flourish close to the sea, growing in sandy soil, while others are more common in the lowlands, inland, or in mountain regions [2, 6]. Their fruits can be harvested from late summer to early spring, depending on the specific type, climate, geographical location, and weather. The appearance, size, and taste of rose hips vary from species to species. While some are small such as medium-sized blueberries, others such as the fruits of *Rosa rugosa* can be as big as a large-sized strawberry, weighing up to 30 grams [author's own experience]. Often, the fruits are orange red in color. However, there are also yellow-green varieties, such as the fruits from *Rosa roxburghii*, or dark purple to almost black fruits from *Rosa pimpinellifolia*. Shape-wise, they vary from oval to flat or round to regular round fruits (**Figure 1**).



Figure 1.
Rosa rugosa berries. One flower is seen in the right lower corner.

2. Rose hip in food and folk medicine

Throughout history, the fruits of the wild roses have been gathered and consumed as food by many different cultures worldwide, especially in the colder regions [2, 3, 6–12]. For example, in North America, rose hips were an important food source during starvation in the winter, where many fruits and berries were no longer available. Specifically, the indigenous people of Canada consumed the raw fruits, as well as boiled them to make tea. Further up north in Alaska, the Inuits mixed rose hip fruits with water, seal oil, and a sweetener to make a pudding [7]. In Europe, many countries with a long history of using rose hips include Portugal, where rose hips were consumed raw as snacks [9]; Turkey, as tea [10]; Hungary, where people made rose hip wine or dried and ground the fruits and used them as substitute for wheat flour during famine [11]; Russia, where fresh rose hips were

added directly to pies, dessert fillings, compote, and brandy, or used roasted fruits of *Rosa canina* as substitutes for coffee [3]. Indeed, according to findings from old Swiss pile buildings, the rose hip fruits were gathered along with other wild foods and used in the younger stone age by people in Switzerland (3710–3677 BC) [8]. In China, some types of rose hips were important ingredients of fermented beverages [12].

Though modern agricultural and health practices have reduced the need for harvesting wild food in large parts of the world, rose hips still play a role in many food cultures. In several European countries, rose hips collected from natural sources are commonly consumed in the form of tea, jam, drinks, wine, and jelly [13]. In Sweden, "Nypon Soppa," a traditional Swedish rose hip soup, has been popular for centuries, and in Poland, people use rose hips as filling in their traditional cake "paczki," a doughnut cake with fruit jam filling. In Turkey, the fruits can be found in juice [14] and food products such as rose hip marmalade and syrup [2]. In Portugal, they are used as children's snacks [9]. Rose hips are also some of the most gathered fruits in Russia, where they are consumed as tea and as ingredients in bread [3].

Besides their culinary use in food products, rose hips can be found as an ingredient in different health supplements [15]. Rose hips from different *Rosa* species have been widely used in traditional folk medicine. The native Americans in North America used rose hips from *Rosa pratincola* for eye- and stomach problems [16], and in China, fruits from *Rosa roxburghii* have been eaten for their detoxifying and heat-clearing effects [12]. In Europe, the fruits from *R. canina* and other species have been commonly consumed to strengthen the immune system and thereby prevent or treat the common cold, flu, and minor infectious disease [10, 17]. In Turkey, a rose hip decoction was used as remedy against diabetes [18] and bronchitis [19], while dried rose hips are used in the treatment of diseases in the liver, bladder, and kidneys in Poland [6]. In Romania and Italy, people have used the fruits from *R. canina* against diarrhea [20], and in Spain, the fruits have been consumed as an astringent and antianemic [21]. In the Middle East, rose hips have been utilized as diuretic [10, 17] and as a remedy against high blood pressure and kidney stones [17]. Apart from the abovementioned applications, rose hips have also been consumed to treat constipation [10]; chronic pain and ulcers [6]; fever and bloody cough [17]; menstrual pain and discomfort [10, 17]; dyspnea [22]; as well as for several anti-inflammatory diseases [23], including rheumatism [22].

Currently, standardized and cultivated rose hips form the basis of an herbal remedy, which consists mainly of powdered dried fruits from *Rosa canina* that is widely sold and consumed to reduce pain associated with arthritis [6]. Rose hips are also used in cosmetics [15] and skin care products. Although this chapter focuses on the fruits of the *Rosa* species, it is worth mentioning here that other parts of the plants such as the roots, petals, and flowers have also been used in traditional medicine [17].

3. The biology of the *Rosa* species

The best characterized species of the *Rosa* genus are *Rosa canina* L. and *Rosa rugosa* Thunb. Whereas the fruits from *R. canina* have been mostly used in traditional medicine, the *R. rugosa* variety is better known for its larger and well-tasting rose hips. Both species are currently used in the production of food products [15, 24], and in some countries, including Denmark, they are grown on an industrial scale [25].

3.1 *Rosa rugosa* Thunb

Rosa rugosa is a small shrub forming dense thickets. It has large white or pink flowers (8–10 cm across) and yields slightly flat round orange fruits, which are some of the largest among rose hips [25]. *R. Rugosa* is also known as Rugosa rose or Japanese rose [6], Beach rose, or Wrinkled rose, deriving the latter name from its distinctive wrinkled leaves. The species originated in Asia, where roots have been used in traditional medicine for many years [24]. It was first introduced to Europe in 1796 as an ornamental plant [26]. However, after 1845, it became a garden escape in many areas, such that it can now be found growing wild in 16 countries including Denmark, Norway, Sweden, Belgium, Austria, the European part of Russia, Germany, and Poland [26]. *R. rugosa* hips can be harvested from late July to early December.

R. rugosa is a strong and hardy plant, capable of living under harsh conditions, including along coastal areas. It easily out-matches other species and its dense shrubs can rapidly spread over larger areas, with the exclusion of many local species. For this reason, *R. rugosa* is considered an invasive species in many European countries. In Denmark, the plant is currently being removed in some areas by the local environmental agencies. However, as indicated by Skrypnik et al, it might be worth considering the rich nutritional content and potential health benefits of this species when discussing whether it should be removed from the environment or not [27].

3.2 *Rosa canina* L.

Rosa canina, also known as the dog rose or dog brier, is a large shrub capable of growing up to 2.7 meter (9 feet) in height [28]. *R. canina* has been used as a medicinal plant since ancient times, where it was first described by Pliny the Elder (23–79 BC), who observed it being used as an antidote against dog bites among French tribes. Hence its name, *Rosa canina* [23]. R. canina is native to Asia and to Europe where it is the most common of the *Rosa* species [28, 29]. It also grows in the wild in North



Figure 2.
Ripe berries from Rosa canina L just after harvesting.



Figure 3.
Rosa canina L in snow. Most berries and fruits from other bushes and trees have fallen during this period and are rotting long before Christmas. In February you can still find intact rose hips. Something must preserve them.

America [29], Africa, Australia, and New Zealand, where it has been naturalized [28]. In addition to growing inland, the species can be found in mountain regions [22]. In contrast to *R. rugosa*, the fruits from *R. canina* are significantly smaller, deeper red in color, and oval-shaped. For more information about the biology of *R. canina*, see the review by Winther et al. (**Figure 2**) [23].

The flowers of *R. canina* start blooming from early summer until the end of the season. As such, rose hips from *R. canina* can be harvested from fall until early March, which is quite exceptional considering that most other fruits and berries are not available during the winter. Refer **Figure 3** for *R. canina* rose hips still on rose bushes in the winter. This could explain why the fruits are so appreciated in the colder northern regions of the earth.

4. Nutritional content of rose hips

Rose hips are known to contain high amounts of nutrients and bioactive substances that positively impact health. The fruits are particularly rich in vitamins, especially vitamin C, A, and E, as well as carotenoids (including beta-carotene and lycopene), essential

fatty acids [30], polyphenols (including flavonoids, proanthocyanidins, catechins), triterpene acid, galactolipid [27], and antioxidants. They also have a noticeable content of dietary fiber compared with other fruits [31]. Regarding the content of bioactive compounds in rose hip seeds, refer the review by Winther et al. [23].

The content of nutrients and bioactive compounds can vary significantly depending on the species [2], ripening state, and environmental factors such as location and growth conditions [27]. Therefore, all rose hips are not equal in terms of their nutritional and bioactive contents. In this chapter, the focus will be on the fruits from *R. canina* and *R. rugosa*, with emphasis on some of the substances that these two species are particularly rich in, such as, vitamin C, specific carotenoids, and antioxidants.

4.1 Vitamin C

Rose hips are some of the richest sources of vitamin C among fruits and vegetables. The water-soluble vitamin is a vital micronutrient, and longer periods of deficiency results in scurvy, a deadly disease that earlier cost the lives of millions of people around the world [32]. The amount of vitamin C needed to prevent scurvy is small (10 mg/day) [33], and the disease is rare in today's societies. However, during times of food crisis or war, when most of the cultivated fruits and vegetables are scarce, access to vitamin-C-rich food, such as rose hips, could play an important role in the prevention of scurvy. For example, during World War II, this was the case in the United Kingdom, where blockages on the sea traffic made it difficult to import citrus fruits from the warmer colonies, rose hips became the country's main sources of vitamin C. For this reason, the British government encouraged people to gather and consume rose hips growing in the wild, to avoid an outbreak of scurvy [34].

In the human body, vitamin C influences many different physiological functions, acting as an important antioxidant and a cofactor in the biosynthesis of neurotransmitters, carnitine, and collagen [35]. The vitamin is also essential to the immune system, where it is found in high concentrations in the leukocytes, the body's immune cells. When these cells are activated by ongoing infections, the local quantity of vitamin C raises many folds. In neutrophils, vitamin C is thought to act as an antioxidant, protecting the immune cells from self-destruction by the reactive oxygen species (ROS) they produce in their fight against foreign pathogens, such as viruses or bacteria [33]. Furthermore, a clinical trial showed that supplementation with dietary vitamin C, given in the form of kiwi fruits, could enhance the function of the neutrophils, by stimulating their movement toward the site of infection [36]. In line with this finding, another study indicated that when patients with impaired immune systems, who were experiencing recurring infections, were given adequate amounts of vitamin C in their diet, their infections ceased [37]. Vitamin C also impacts other aspects of our health such as our cognitive functions [38], mood and energy, and common symptoms of low vitamin C intake includes irritability, fatigue, and decreased antioxidant capacity [35].

The daily recommendation for vitamin C varies greatly from country to country, with 40 mg/day in India and the United Kingdom, to 110 mg/day in Germany and France [39]. However, some authors argue that the body needs 200 mg/day to sustain good health [33, 40]. The vitamin C content in rose hips differs among *Rosa* species (**Table 1**) [48]. Furthermore, the vitamin content varies also with other factors such as growth location [27, 41] and the ripening state of the fruits [27, 30]. Generally, fruits from *R. rugosa* generally contain high amounts of vitamin C, from 600–1090 mg/100 g dried fruits [25, 31, 42, 43]. In *R. canina* the vitamin content varies significantly, from

Food	Vitamin C in mg/100 g
Kakadu-plum, raw	2300–3150
Rose hip, Canina, raw	274–2700
Acerola, raw	1677
Rose hip, Rugosa, raw	600–1090
Blackberries, raw	181
Red pepper, raw	179
Kale, raw	169
Sea buckthorn, raw	131
Lemon peel	129
Broccoli, raw/boiled	111/40
Strawberry, raw	67
Kiwi, raw	63
Orange, raw	54
Lemon, raw	49
Potato, raw/boiled	26/8

Sources: [31, 41–47].

Table 1.
Vitamin C content in selected berries, fruits and vegetables.

274 to 2700 mg/100 g [41, 44, 45]. By contrast, in the few studies, where the content of vitamin C was compared in both strains, *R. canina* was found to contain significantly lower levels of the vitamin, as compared with the levels in *R. rugosa* [6, 27, 30].

4.2 Carotenoids

Rose hips from *R. rugosa* and *R. canina* are rich in carotenoids, including beta-carotene and lycopene—plant color pigments that give fruits and vegetables their characteristic orange and red color [15]. Both carotenoids have well-known antioxidant effects [35], with lycopene being the most potent antioxidant among carotenoids [49]. Moreover, beta-carotene is a precursor for the biosynthesis of vitamin A, a fat-soluble antioxidant that is vital for our sight and skin. The vitamin is also essential for the immune system, such that one of the signs of vitamin A deficiency is an impaired resistance to infections [35]. While beta-carotene is the most abundant carotenoid in fruits and vegetables, lycopene-rich foods are fewer in number [50, 51]. Lycopene has recently gained a lot of attention in the field of health science, and a growing number of studies have linked the intake of this carotenoid with a decreased risk of cardiovascular disease [49, 52]. A meta-analysis from 2017 supports this indication of carotenoids by concluding that an increased intake of lycopene-rich food, including tomato products, could have a positive effect on blood pressure and endothelial function [53].

The content of beta-carotene and lycopene varies significantly in rose hips from both *R. canina* and *R. rugosa*. The fruits from *R. rugosa* have been shown to contain circa 11,4 mg/100 g of total beta-carotene [31], which is one of the highest contents among fruits and vegetables, ranking higher than carrots (9,7 mg/100 g). The beta-carotene

content in *R. canina* fruits varied in one study from 1,2 to 2,9 mg/100 g (measured as (all-E)-beta-carotene) [54], which is significantly lower. However, in a comparative study with both species, the amount of beta-carotene (measured as (all E)-beta-carotene) was higher in *R. canina* fruits; 4.2 mg/100 g, compared with *R. rugosa* fruits; 3.2 mg/100 g [15].

It should also be noted that in the comparative study with both *R. rugosa* and *R. canina*, their content of (all-E)-lycopene ranged from 7.4 to 7.9 mg/100 g [15], which is higher than other well-known lycopene rich foods such as tomatoes (0.7–4.2 mg/100 g), pink guava (5.2–5.5 mg/100 g), and like that in watermelon (2.3–7.2 mg/100 g) [51]. In another study, fruits from *R. canina* had a significantly higher content of (all-E)-lycopene and total lycopene, ranging from 9 to 22.9 mg/100 g and 12.9–35 mg/100 g [54]. The amount of lycopene is known to vary significantly in fruits and vegetables. Factors that affect the content include ripeness of the fruits, quality of the soil, and weather temperature [51].

4.3 Antioxidants

Rose hips are an exceptional source of antioxidants. In a study where over 3100 foods from around the world were tested, rose hip from *R. canina* was one of the foods with the highest antioxidant content among berries, fruits, and vegetables (**Figure 4**) [55]. In another study where rose hips from different species were compared, the fruits from *R. rugosa* had a slightly lower antioxidant content than fruits from *R. canina* [29].

Dietary antioxidants protect the cells and tissue against free radicals and radical oxygen species (ROS). ROS are a group of highly reactive chemicals containing oxygen that are produced either exogenously or endogenously, during normal biological functions such as immune response, cell differentiation, growth, and proliferation. Overactivity of ROS has been associated with a wide variety of human disorders, such as chronic inflammation, age-related diseases, and cancers.

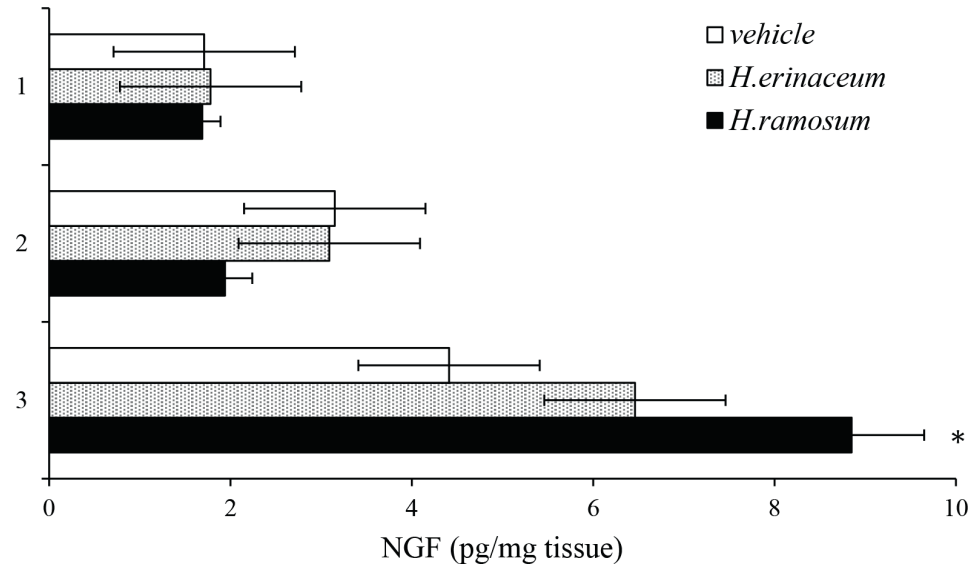


Figure 4.
Antioxidant content of different foods and drinks (mmol/100 g). The content of antioxidants is measured by the FRAP-method. Sources: [55, 56].

An example of this is seen in the bloodstream where vitamin C, along with other antioxidants, protects LDL-cholesterol, thus preventing the fatty acid molecule from getting stuck the arteries, in an event that can ultimately lead to arteriosclerosis [57]. ROS are constantly produced in the body, creating a demand for a steady supply of antioxidants from the diet to keep the reactive species in check. An imbalance of ROS and antioxidants, which results in an excess of the ROS, can lead to oxidative stress, a condition akin to overactivity of ROS [35] and therefore, any of the human disorders [49]. Some of the main antioxidants found in rose hips from the two species include vitamin C, E, and A, beta-carotene, lycopene, and flavonoids. **Figure 4** shows the antioxidant content in *R. canina* fruits and other selected foods measured by the FRAP-method (Ferric Reducing Ability of Plasma), one of several ways of measuring the antioxidant content in foods.

5. Rose hip as a medicinal plant

As mentioned previously, rose hips are used worldwide as folk medicine and sometimes also as food. In this section, the focus is on the medicinal properties of the fruits. Prescription medicine that is purchased from a drug store often has documented dose dependency, indicating that the more you take of the remedy, the more impact there will be on the body. An interesting question is—can such dose dependency be shown for an herbal remedy like rose hip? It should also be stated that whatever is indicated for rose hip as regards the effect on different diseases, is only relevant for the subspecies being considered or tested, as such effects may not be relevant for other rose hip subspecies. Furthermore, the active ingredients in the shells of the rose hips are very different from that within the seeds (**Figure 5**) [23]. A product consisting of shells alone can therefore have very different content regarding the amount of different active ingredients when compared with a product consisting of seeds alone or the combination seeds and shells—not to speak about preparations made from the leaves or roots of rose hip [23]. The content of active ingredients, besides what is related to differences within species and subspecies [15, 58], is also dependent of where the plant is grown—on the soil, number of hours with sun and altitude [41] as earlier stated.

The best method for demonstrating the medicinal properties of drugs is the randomized, double-blinded, placebo-controlled study. Unfortunately, established pharmaceutical companies are rarely interested in herbal remedies. Therefore, much of the research on the different species of rose hip has been performed only in animal models or in *in vitro* systems. Due to the huge variations in rose hip species and subspecies, as regards their content of active ingredients, the version of rose hip species/subspecies tested and sometimes also the manufacturing process will be stated. So far, the temperature at which the rose hips are dried during the manufacturing process of the herbs has been found to be very important [23]. This insight was first made by a Danish farmer, Erik Hansen, who recognized that he often lost his farm animals (e.g., cattle or horses), when their body temperature went above 42°C for a few hours. Upon coupling this observation with the knowledge that some of his friends also died when their body temperature went beyond 42°C even for short periods, Erik Hansen postulated that likewise, maintaining the rose hips to temperatures above 40°C for hours during the drying process would also be detrimental for the bioactive components in the fruits that have beneficial health effects. Hence, he invented and standardized a new method for storing rose hip for the winter season. In this process, the rose hips are never heated to more than 40°C. Moreover, the seeds and shells are separated and dried separately before milling, resulting in a rose hip powder, which



Figure 5.
One rose hip fruit with seeds exposed.

still contains all that was in the fruit on the day of harvest, except for the well-known itching hairs, which are removed. Eating the powder containing seeds and shells is therefore like eating a rose hip fruit picked from a bush. Refer **Figure 6** for the dried seeds and shells before and after the milling process. This methodology is in sharp contrast to rose hip products from Chile (a major exporter of rose hip worldwide), where the seeds are often removed from the fruits, before drying them at high temperatures resulting in powders, which are more brownish in color [23]. Only very few rose hip preparations have been tested in well-designed clinical trials. But there are many different preparations available in the health stores. However, the content of active ingredients is very dependent on how the powder (if powder) was produced and if an extraction, then how was the extraction methodology, for that particular product. In addition, one should consider whether the preparations include shells or seeds only or a combination of seeds and shells.

5.1 Can administration of rose hips improve the immune system?

As previously indicated, there are numerous claims in folk medicine worldwide, that rose hip improves the functions of the human immune system. Not surprisingly therefore, the anti-inflammatory effects of *Rosa canina,* subspecies Lito, (referred to in some studies as Hyben Vital), which contains both seeds and shells dried at low temperatures, have been shown to have anti-inflammatory properties when tested in humans. It was also documented that the preparation contained a compound capable of inhibiting the chemotaxis of neutrophil leucocytes *in vitro* and in lowering the levels of the anti-inflammatory marker, C-reactive protein (CRP), in human volunteers treated with rose hip at high doses for a month [59]. Likewise, in a study on volunteers with osteoarthritis and treated with the same rose hip powder at low dose (5 gram daily) for 3 months, CRP was significantly reduced when comparing the



Figure 6.
Seeds and shells from rose hip dried at low temperature and then milled.

rose hip–treated group with placebo [60]. A significant reduction in the inflammatory marker—erythrocyte sedimentation rate (ESR) was also observed in the test group of a placebo-controlled study, where 5 gram of the same *R. canina* species was administered to rheumatoid patients for 6 months [61]. It is interesting to note that in these two studies, administration of a preparation composed of only the shells of rose hip did not cause significant changes in CRP levels [62, 63].

Another interesting query was: will rose hip treatment influence the likelihood of catching a flu or the common cold during the winter season? This was investigated in a clinical study, where rose hip shells (2 grams dispensed in liquid form) of the Lito subspecies or placebo were administered daily to 120 middleclass volunteers from the autumn season, for a total of 6 months. After 2 months of treatment, there was a statistically significant reduction in the number of volunteers catching a cold in the actively treated group when compared with placebo. In addition, the different symptoms related to colds were significantly reduced as the result of rose hip treatment. There was no statistically significant change in the likelihood of getting the flu. The levels of the inflammatory marker, CRP, were also not affected in this study [63].

It would be interesting if more studies were available on the effects of rose hip treatment on the immune system, especially as regards the studies involving rose hip preparations consisting of both seeds and shells. Preliminary results currently available suggest that the anti-inflammatory properties of rose hip formulations containing both seeds and shells may be stronger than preparations with shells alone. It is interesting to note that the number of colds was also influenced by elderberry, which has much in common with rose hip regarding bioactive ingredients [64].

5.2 Can rose hip treatment impact cardiovascular disease, hyperlipidemia, or glucose metabolism?

Hyperlipidemia and disturbances of glucose metabolism can predispose to cardiovascular disease, which is still a main killer worldwide [65]. A rose hip preparation

based solely on powdered rose hip shells from Chile, administered for 6 weeks, at a daily dose of 40 gram in apple juice, citric acid, and sugar was tested in a randomized, placebo-controlled study.

In the actively treated group, there was a statistically significant 3.4% reduction in systolic blood pressure, while total cholesterol and LDL cholesterol fell by 4.9 and 6.0%, respectively [66]. There was no change in glucose tolerance or markers of inflammation between the treatment and placebo groups. Testing a pure shell liquid product from subspecies *Rosa canina* Lito [60] in a far lower dose (2 gram daily) for 6 months revealed a 4% drop in total cholesterol, when comparing groups. Blood pressure tended to decline because of active treatment. In accordance with these findings, a statistically significant reduction in total cholesterol of 8% and a statistically significant improvement in HDL cholesterol of 2% were observed in two other randomized placebo-controlled clinical trials, while testing a combined shell-seed rose hip powder, of the subspecies Lito, for 3 and 6 months, respectively [60, 67]. The dosage tested was 5 gram of dry rose hip powder daily. Rose hip powder (species and shell/seed content not defined) was shown to exert antiatherosclerotic effects by reducing atherosclerotic plaque formation in mice [68]. At present, there are no studies available focusing on plaque formation in humans. We were not able to find any indication of an impact on glucose metabolism from any subspecies of rose hip—not even when rose hip was tested in the high dose of 40 g of shells [66] or 40 grams of seeds daily (personal communication, Kaj Winther). For that reason, we assume that rose hip does not affect blood glucose levels.

In conclusion: It seems that rose hip can modify lipid metabolism. This can possibly be related to the shells as shell-only powders [62, 66] as well as combined shell/seed powders [60, 67] were able to improve the lipid profile. Such declines were not observed when testing a seed only product in high concentration (personal communication, Kaj Winther). Seeds from rose hip contain high amounts of polyunsaturated fatty acids, among them omega-3 and omega-6. Omega 3 and omega 6 acids [69] possibly supported by certain antioxidants may explain why rose hip powders containing also seeds [59–61] show more anti-inflammatory property than shells-only products [62, 63, 66]. It has not been possible to find any indications of an impact from any version of rose hip on glucose metabolism in humans although a few animal studies look promising.

5.3 Effect of rose hip on obesity

During the last decades, obesity rates have exploded among the young and the elderly, so that we have a worldwide epidemic. The mass movements of people from the rural areas into cities have caused great changes in lifestyles and diets. So many people now sit in front of their computers, as compared with carrying out physical work. These changes in lifestyle and the accompanying diseases confer great costs to the society. To control the obesity epidemic, there is a now a great focus on diets and food supplements. Seeds from rose hip contain high amounts of tiliroside, not present in the shells [23]. In a study performed on mice, Niomiya et al [70] found that extract of the seeds of *Rosa canina* that was rich in tiliroside, as well as pure tiliroside isolated from *Rosa canina*, significantly reduced body weight and visceral fat gain after a treatment period of 14 days or less. In the same period, a reduction in plasma triglyceride and fatty acids was also observed. Not surprisingly, these desirable alterations were ascribed to tiliroside. Later the same group of researchers designed a randomized, placebo-controlled and double-blinded study on humans in which they showed that rose hip seed extract containing tiliroside given daily for 3 months resulted in a

significant reduction in abdominal visceral fat, body weight, and body mass index [71]. It was therefore concluded by the authors that rose hip seeds can be useful for the treatment of obesity in humans.

5.4 Effect of rose hip on osteoporosis

Loss of bone strength or osteoporosis has improved during the last century, possibly due to a combination of changes in our diet and our general reduction in physical activity. Osteoporosis is a serious threat to the public health system as loss of bone strength can lead to bone fractures and disabilities and in the elderly loss of height, due to loss of strength of thoracic and lumbar vertebrae. Such loss of height can limit important body functions and thereby quality of life. Bone formation is regulated by osteoblasts, which improves bone formation and osteoclasts, which facilitates destruction of calcified tissue (break down of bone structure). ROS (reactive oxygen species) are produced by osteoclasts, and ROS improves the destruction of collagen strands, which are important in bone remodeling [72, 73]. An increase in oxidants can also activate proteolytic enzymes such as elastases and metal proteinases resulting in a further damage of bone extracellular matrix [71]. Therefore, supplementation with antioxidants can support the restauration of bone mineral density (BMD). In a rat model, blueberries, rich in antioxidants, were shown to reduce the loss of BMD especially in the tibial and femoral area [71]. Extracts of different versions of rose hip have a phytochemical profile close to that of blueberry and have been suggested to play a role in preventing bone loss [74]. Indeed, rose hip was rated in the top three regarding antioxidant concentration when testing berries worldwide. And rose hip was rated at least three times more potent than blueberry (**Figure 4**) [74, 75]. In addition, rose hip also contains abundant amounts of vitamin C [23] (only one berry, Cockatoo Plum well known in Australia, is superior to rose hip regarding vitamin C content), as detailed in **Table 1**. Vitamin C (ascorbic acid) is an important player in regulating osteoblast differentiation and is important for secreting procollagen and stable collagen, which is needed for the growth of connective tissue and bone tissue [76].

Another argument for a positive role for rose hip treatment in osteoporosis is that the fruits contain a high number of polyphenols [77, 78], which are known to reduce bone loss resulting from oxidative stress [79]. A clinical study on humans showed that a subspecies of *Rosa canina* (Lito) was able to improve wrinkles of the skin [80], and it was further documented in human cartilage cells from the knee that the same rose hip subspecies supported the formation of collagen [81].

In summary: Rose hip is a very strong antioxidant, and there are indications that antioxidants can improve BMD in animal models. Rose hip can also improve bone quality from the impact of its rich sources of vitamin C, which improves the formation of collagen. Terpenes, abundant in rose hip, have also been proven to reduce bone loss, and rose hip (Lito) was also shown, in human knee cells, to inhibit the formation of MMP-1 (a metalloproteinase) known to impact bone loss. So even we still need a well-designed and large-scale clinical trial to document the impact of rose hip on bone density in humans—there are many indications that rose hip can support bone quality.

5.5 Effect of rose hip on arthrosis and rheumatoid arthritis

One of the larger limitations of quality of life in the elderly is osteoarthritis, which is present in more than 60% of people above 50 years of age. Osteoarthritis is often recognized in the hip, knee, spine, or hand and can reduce quality of life from simply

the pain, which occurs from joints where the cartilage is disrupted and also from the inflammation, which can follow the destruction of cartilage.

Limitations in joint movements and pain can reduce the amount of physical activity and in the long run lead to a decline in muscular mass. It becomes more difficult to climb a staircase, ride a bicycle, or to enter a car. This can result in a reduction in social activities and finally a more limited lifestyle [79]. Treatment of osteoarthritis is initially often simply to try and cure symptoms such as pain. First choice of pain cure can be painkillers such as paracetamol and/or nonsteroidal anti-inflammatory agents (NSAIDs). Later on, synthetic opioids (Tramadol) may follow [82]. However, such medication does not repair the reason for pain (cartilage which is destructed). Painkillers only treat symptoms—and on the side—they have side effects such as gastrointestinal bleeding, heart problems, and liver damage [83–87]. Literally, what health professionals are often doing is that they place a bucket on the loft, to catch the water dripping from the destroyed roof instead of repairing the hole in the roof by placing a new roof tile. So, any herbal remedy, which reduces pain and even better also supports the restauration of cartilage, is of high interest in osteoarthritis.

Rheumatoid arthritis is a chronic, inflammatory, and autoimmune disease affecting the joints and also shortening life. Most common symptoms are pain, swollen joints, stiffness of joints, and loss of function. The initial treatment is usually disease-modifying antirheumatic drugs (DMARDs) often supported with pain killers such as paracetamol or nonsteroidal anti-inflammatory drugs (NSAIDs), which as earlier described have side effects. So, any herbal remedy, which can reduce pain and even better support repairment of the body, is of value also in rheumatoid arthritis.

Osteoarthritis is the disease in which rose hip (*Rosa canina*) has been tested the most, as we were able to find a total of six randomized, placebo-controlled, double-blinded clinical studies performed in humans. Five of these studies tested a powdered version of *Rosa canina* subspecies Lito, containing seeds as well as shells dried at very low temperature [23]. The background for this methodology was, as earlier discussed, that heating to more than about normal body temperature might destroy active ingredients in seeds and shells. These five studies focused on osteoarthritis of the hip, knee, and hand. The sixth study was focusing on osteoarthritis of the knee and was based on a product consisting of powdered shells only originating from Chile without any seeds added. The temperature during the preparation procedure was not given, but presumably it was high as most products from Chile are heavily heated [23]. Finally, there was a meta-analysis based on the shell and seed version of rose hip. There were two studies on rheumatoid arthritis, both placebo-controlled and based on the seed and shell version of rose hip.

If not stated, the treatment period was invariably 3 month and the dosage 5 gram daily of powdered rose hip containing seeds and shells served in capsules.

When focusing on osteoarthritis using the combined seed and shell powder, there was a significant reduction in reported pain and stiffness in all five studies [60, 67, 88–90]. In addition, there was also an improvement in general well-being and daily activity such as climbing a staircase, visiting the toilet, or entering a car. The improvement in daily activity was possibly the result of less pain and less stiffness in joints [60, 67, 88–90]. It is interesting to note that in four of the five studies, one study [60] was presented as a dose finding study, indicating dose dependency, there was a significant reduction in the consumption of rescue medication such as paracetamol, tramadol, or NSAIDs [67, 88–90]. This is of some interest as the volunteers in all studies were told not to change the consumption of rescue medication—even though they did so.

See details in **Figure** 7.

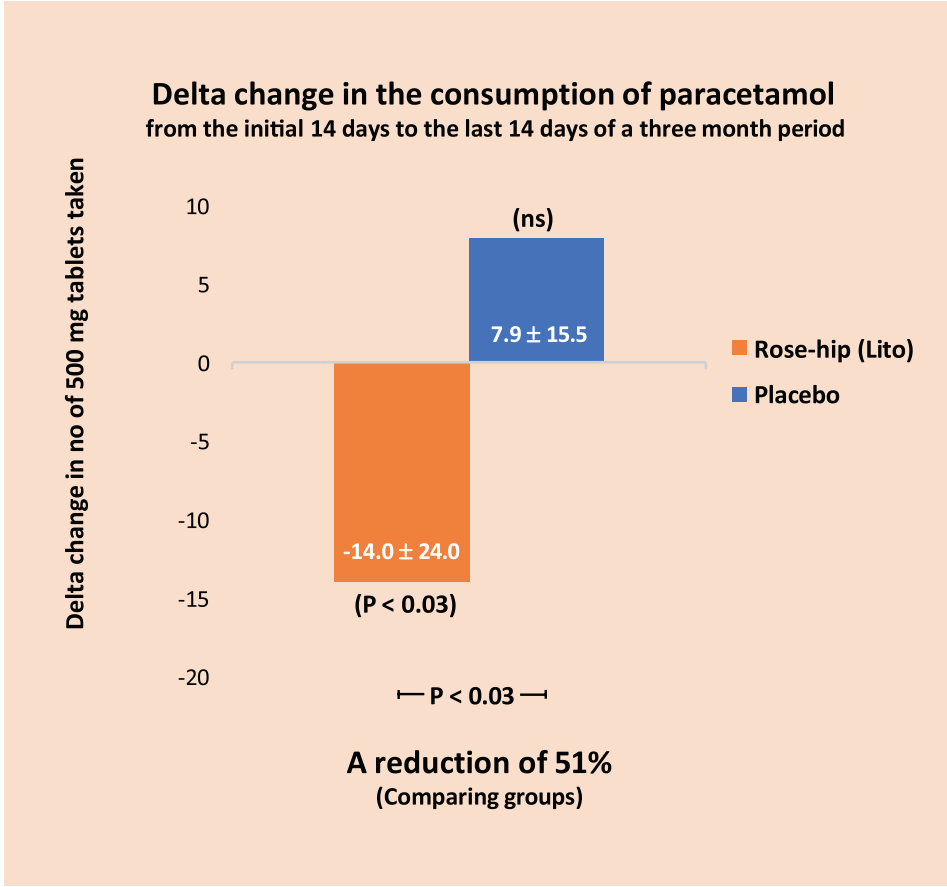


Figure 7.
Delta change in the consumption of 500 mg paracetamol tablets. The delta change is the delta value of the first fourteen days minus that of the last 14 days of a three-month treatment period.

When testing the shells only powder (2.225 gram daily), there were no impacts on what patients reported on symptoms such as pain, stiffness, daily activity, or quality of life and neither on the consumption of rescue medication. However, some improvements in knee function could be detected when using gait analyzing in a motor function laboratory [63].

A meta-analysis indicated that the Lito rose hip subspecies significantly reduced pain in osteoarthritis and that the effect size was better than what was observed for paracetamol [91] and comparable to what was seen for NSAIDs [92, 93]. Details are shown in **Figure 8**.

One of the two studies on rheumatoid arthritis only lasted for 1 month, and results were not conclusive [94]. The other study lasted for 6 month, and after 3 month there was a statistically significant improvement in daily activity scores, which was maintained also after 6 months of treatment. After 6 months, there was a further statistically significant improvement in patients as well as doctor's evaluation of disease severity and in quality of life using SF questionnaires [61].

In summary: There are strong indications that the combination of seeds and shells from subspecies of *Rosa canina* exerts a reduction in pain and an improvement in daily

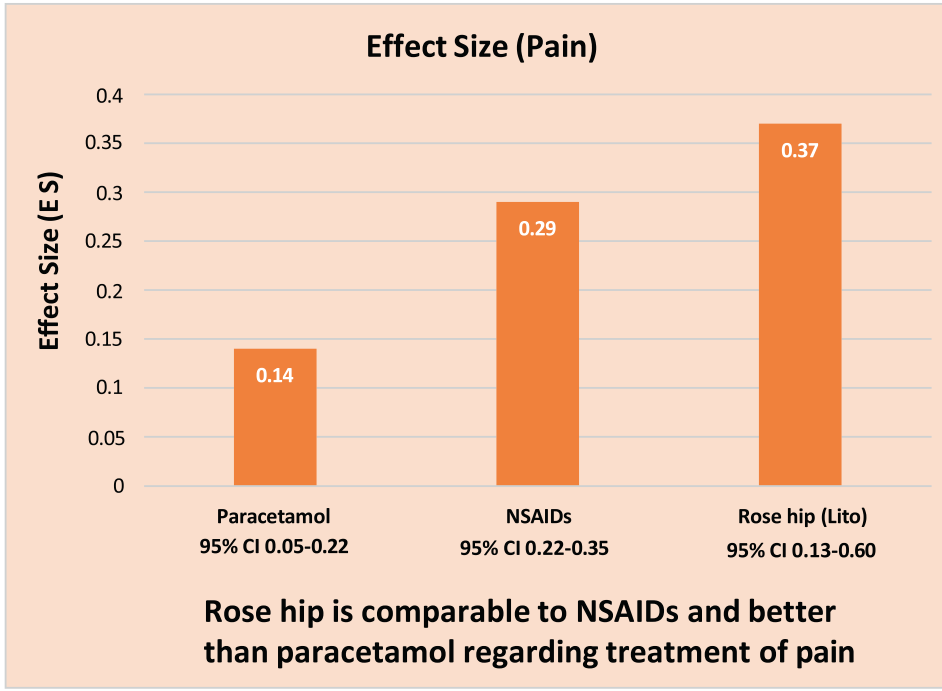


Figure 8.
Effect size of Rosa canina (Lito) right panel, to that of NSAIDs (mid panel) and that of paracetamol (left panel). It should be recognized that the Effect Size of rose hip is close to three times higher than that of paracetamol.

function in osteoarthritis and that the same remedy can be of some benefit to sufferers of rheumatoid arthritis [61, 91]. Other subspecies including subspecies from *Rosa rugosa* can have similar effects; this however remains to be established. From the present evidence it seems clear that both shells and seeds are needed as a study on shells-only did not show any impact on the pain and discomfort reported by patients [63].

However, the biochemical background for the beneficial effects of *Rosa canina* still remains to be fully elucidated. It was encouraging to note that C-reactive protein (CRP) fell in two studies on osteoarthritis [59, 60]. In a study on rheumatoid arthritis, there was a significant reduction in sedimentation rate, an inflammatory marker [61]. Again, no such changes in inflammatory markers were seen testing shells-only powders [62, 63]. From the insight we have today, it seems that a certain molecule, a galactolipid named GOPO, which acts as an anti-inflammatory agent, is important [95]. The high amount of natural vitamin C, present in *Rosa canina*, and easily absorbed [96] can play an important role for restoring collagen. Also, linoleic and alpha-linolenic acids, which contribute to the COX-1 and COX-2 inhibitory effects observed in rose hip together with triterpene acids, can add some clarification [97, 98]. And finally, the reduction in the synthesis of MMP-1 responsible for the breakdown of collagen can play an important role [81].

5.6 Rose hip for managing renal disturbances

The kidneys can be damaged in diseases such as diabetes and hypertension. In addition, the formation of stones in the kidneys gives rise to painful and

dysfunctional condition. Acute kidney injury is defined as a disorder with disruption of kidney function leading to renal failure. Two major reasons for acute kidney injury are inflammation and oxidative stress. A correlation between a reduction in oxidative stress and a reduction in renal failure was observed in a study where rats with induced acute kidney injury were fed *Rosa canina* [99]. Similar results involving ameliorating renal failure were also observed in another group of rats treated with *Rosa laevigata* [100], as well as in rats suffering diabetes [101, 102].

Prevention strategies for avoiding calcium oxalate nephrolithiasis (kidney stones) are important and on demand. *Rosa canina* extracts have been tested and shown to reduce the number of calcium oxalate calculi and prevent nephrolithiasis in treated rats [103]. On the other hand, human studies for the effects of rose hip treatment on kidney dysfunction are lacking. However, it was encouraging to note that serum creatinine, a marker of kidney function, significantly improved in a human study with *Rosa canina* Lito [59].

5.7 Rose hip in liver protection

As we earlier stated from our search on folk medicines, rose hip has been claimed to act as a detoxifier. So, are there any indications that rose hip can support the liver? Hepatic injury (liver toxicity) is often characterized by lipid peroxidation, the production of free radicals, and a reduction in antioxidant enzyme activity. Among blood analyses, which can describe to what extend the liver is injured, there are serum alanine transaminase (ALT) and serum aspartate transaminase (AST). Due to our lifestyle, which for many include overeating, consumption of high amounts of alcohol and for some people also sometimes the consumption of different versions of medicine—foods and food supplies, which can protect the liver, has drawn increasing attention. In a study on rats where liver injury was induced, *Rosa canina* restored the abovementioned marker enzymes as well as histopathological alteration caused by the injury. The authors of the paper found a reduction in ALT and AST as the result of treatment and suggested that *Rosa canina* may exert its liver restoring capacity from its content of antioxidants and phenolic compounds [104]. In another study on diabetic rats testing the impact of *Rosa rugosa* on accumulation of fat in the liver, there was also a reduction in ALT and AST as the result of treatment together with a reduction in fat accumulation in the liver [105]. In a study on humans, consuming 45 gram daily of powdered *Rosa canina* from the subspecies Lito containing seeds and shells, given for 1 month, did not affect ALT [59]. However, treating 40 g daily of pure seed powder from the same subspecies for a full 3-month period resulted in a statistically significant drop in ALT (personal communication, K. Winther). This may indicate that also compounds related to rose hip seeds can be important when discussing the protection of the liver, and possibly 1 month of treatment is too short a timeframe when testing the impact of an herbal remedy on liver protection in humans.

In conclusion: From the literature available, it seems like different families of rose hip can be of interest when developing a treatment or a diet, which exerts some liver protection.

5.8 Rose hip for treating skin disorders and aging

Chronic inflammatory skin disorders (dermatitis) are common in humans of all ages, and we all get facial wrinkle as we get older than 50 years of age. Anti-inflammatory

remedies can reduce the numbers and depth of wrinkles. The two main factors that determine aging of the skin are a) aging associated with time and b) aging resulting from exposure to UV, also known as "photo aging." The combination of these two factors results in loss of functionality of the skin as a barrier against "the outer world." Therefore, dryness, wrinkles, and spots (melanomas) occur. Consequently, protecting the aging skin with anti-inflammatory agents and antioxidants is very important [106].

An extraction of the root of *Rosa multiflora* was recently reported to improve dermatitis in an animal model via COX-2 inhibition. *Rosa multiflora* root extract that is rich in tannins was also shown to be antiallergic by lowering the number of eosinophil leucocytes in another animal model [107, 108]. Interestingly, quercetin isolated from *Rosa canina* was found to lower the melanin content in mouse melanoma cells, while oral administration of rose hip reduced skin pigmentation in guinea pigs [109, 110].

One human study demonstrates that a *Rosa canina* subspecies can influence skin wrinkles, the moisture of the skin, as well as skin elasticity [80]. The study was double-blinded and randomized, lasted 8 weeks, and included 34 volunteers. The effects of *Rosa canina* Lito were compared with a well-known antiwrinkle remedy, Astaxanthin. After 8 weeks of treatment, there was a significant reduction in the depth of crow feet wrinkles as the result of oral rose hip treatment. Similarly, skin moisture and skin elasticity were also significantly improved. The impact was comparable with that of Astaxanthin, which is a strong antioxidant containing the carotenoid pigment. Carotenoid pigment is also found in the rose hip preparation used [23], which is a strong antioxidant too, and rich in several xanthins and able to inhibit the synthesis of MMP-1, an enzyme responsible for the breakdown of collagen [81]. Such strong antioxidant may help to protect collagen and elastin from free radicals formed by UV-induced oxidation, which is responsible for skin aging [109, 110]. It is indeed interesting to note that the actual version of rose hip has been documented to improve collagen [81] and symptoms of osteoarthritis [67, 89–91]. In osteoarthritis as well for the skin, collagen plays a very central role. Another aspect of rose hip impact on the skin is GOPO and its anti-inflammatory property [59, 97]. GOPO was shown to inhibit the chemotaxis of neutrophils and the production of interleukins [59]. Inflammation is a key factor of particular interest as UV radiation is known to result in cell destruction and inflammation. Anti-inflammatory agents therefore have their place as a treatment. It should also be remembered that rose hip seeds and oil from these seeds are used to restore burn injury and restore scars in South America. As earlier stated, seeds from rose hip are also rich in poly unsaturated fatty acids (PUFA), among them linoleic acid and alpha linolenic acid [99], both major constituents of the barrier function of the epidermis [111, 112].

When human erythrocytes are stored in a blood bank, they can normally be stored for up to 5 weeks before the hemoglobin starts to leak out through the erythrocyte membranes as an indicator that the membranes are now disintegrating (getting older). Eighteen healthy volunteers were given 45 gram daily of rose hip powder (Lito) containing seeds and shells for 4 weeks and compared with a group of controls. It was shown that the leak of hemoglobin from red cells, in these volunteers, when stored in a blood bank, was significantly reduced because of treatment with rose hip [80]. Details are shown in **Figure 9**. This was evident after 14 days of treatment and remained for the entire treatment period. This indicates that cell membranes from human erythrocytes, when stored in a blood bank, survive longer before they disintegrate if

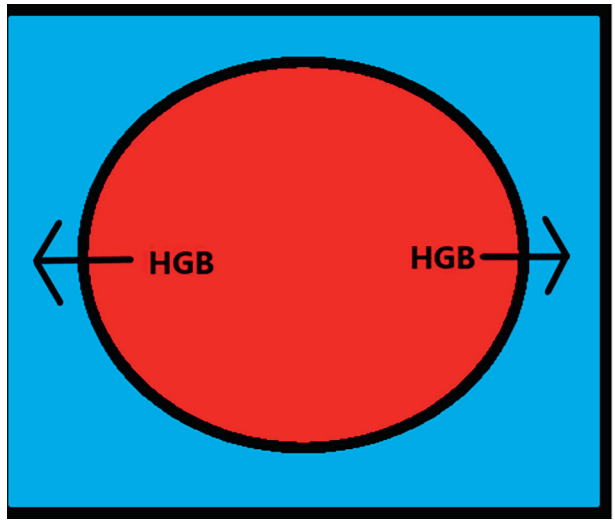


Figure 9.
Hemoglobin is leaking out through the erythrocyte membrane as the result of disintegration over time (aging) of the membrane. If human volunteers are treated Rosa canina this leak of hemoglobin is lowered indicating that membranes are now more resistant to disintegration.

volunteers have been treated rose hip the latest month before blood sampling. There is improved longevity of the red cell membranes as the result of rose hip treatment.

In summary: rose hip can influence wrinkles, moisture, and elasticity of the skin, as well as add to the longevity of red blood cells stored in a blood bank. The mechanism behind these properties is believed to be dependent on the antioxidant activity, as seen in the ability of rose hip to suppress the activity of matrix metalloproteinase 1 (MMP-1) that is involved in the breakdown of extracellular matrix and in particular, tissue remodeling. The result of MMP-1 suppression is also supportive to collagen. Anti-inflammatory capacity and certain fatty acids that are present in the seeds and shells are also thought to play an important role here.

5.9 Rose hip and diseases related to the gastrointestinal tract

Antiulcerogenic activity from "folk remedies" has often been reported, and in this connection, *Rose canina* L is also mentioned [113]. An antiulcerogenic effect from *Rosa canina* extracts was discovered in a rat model. It was later shown that *Rosa canina* can prevent gastric mucosa erosion and the associated hemorrhagic ulcer formation [114]. Extracts from the leaf of *Rosa canina* were also reported to have significant antidiarrheal activity, as well as significantly reduce the intestinal transit time in another animal study [115]. In a clinical trial on humans suffering either Morbus Crohn or Ulcerative colitis, it was documented that the combined seed and shell powder from *Rosa canina* (Lito) significantly lowered symptoms from Morbus Crohn but not symptoms from Ulcerative colitis [116]. One reason for that phenomenon can be that the rose hip version used in the experiment could inhibit neutrophil chemotaxis [59]. Excessive neutrophil activity is involved in the pathogenesis of Morbus Crohn.

In conclusion: Rose hip is interesting when focusing on the gastrointestinal tract, especially by impacting the gastro microbiome. However, more clinical studies in humans need to be available before making any conclusions.

5.10 Antiproliferative effects of rose hip

The involvement of ROS and free radicals in the pathogenesis of certain human diseases also including aging and cancer is increasingly recognized [117], and there are an increasing number of papers in which *Rosa canina* L has been tested on different cell lines in the laboratory. Such studies include colon, lung, and prostate cell lines in which cell proliferation and apoptosis have been reported [118, 119]. However, we were not able to find any clinical studies performed in humans that specifically focus on the impact of any rose hip species including *Rosa canina* on the survival rate among humans suffering from cancer. And as we do not want to create false hopes in people experiencing such a serious disease, our statement is: That from the present knowledge and insight it is too early to discuss the possible impact rose hip treatment might have on proliferative disorders in humans.

6. Conclusion

Rose hip is a very fascinating medicinal plant, which deserves much attention. It can grow on very poor soil, and it is a source of very potent antioxidant and anti-inflammatory agents. It is also a rich source of vitamins—especially vitamin C. Several clinical studies have established that rose hip is very effective for the treatment of osteoarthritis in humans and also in some animal models. Very important, dose dependency, one of the cornerstones when evaluating prescription medicine, has been documented for a subspecies of rose hip [60]. There are also indications that conditions such as rheumatoid arthritis, cardiovascular disease, and skin diseases including wrinkles can benefit from rose hip treatment. However, there are many different *Rosa* species that produce rose hips with varying contents of active compounds. Only careful comparative evaluation will establish which species are most promising. Currently, it seems like a certain subspecies of *Rosa canina* Lito is very promising. There is still a tremendous amount of research to be done before we have a clearer pattern. But for sure, rose hip is a medicinal plant with a long and fascinating history. When discussing anti-inflammatory diets and anti-inflammatory plants especially it is interesting to note that in osteoarthritis a subspecies of *Rosa canina* was able to reduce the consumption of rescue medication by up to 50%. This means that we can eat in a different way and possibly, spare governmental health expenditure for medicine. It has been very interesting to be part of this research.

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References

[1] Senapati K, Rout GR. Study of culture conditions for improved micropropagation of hybrid rose. Horticultural Science. 2008;**35**(1):27-34

[2] Ercisli S. Chemical composition of fruits in some rose (Rosa spp.) species. Food Chemistry. 2007;**104**:1379-1384

[3] Shikov AN et al. Traditional and current food use of wild plants listed in the russian pharmacopoeia. Frontiers in Pharmacology. 2017;**8**:841

[4] Ghazghazi H et al. Phenols, essential oils and carotenoids of Rosa canina from Tunisia and their antioxidant activities. African Journal of Biotechnology. 2010;**9**(18):2709-2716

[5] Britannica T. Editors of Encyclopaedia. "rose". Encyclopedia Britannica. 2021. Available from: https://www.britannica.com/plant/rose-plant [Accessed: April 15, 2022]

[6] Czyzowska A et al. Polyphenols, vitamin C and antioxidant activity in wines from *Rosa canina* L. and *Rosa* rugosa Thunb. Journal of Food Composition and Analysis. 2015;**39**:62-68

[7] Kuhnlein HV, Turner NJ. Traditional Plant Foods of Canadian Indigenous Peoples: Nutrition, Botany and Use. Second ed. Australia, Canada, The Netherland, United Kingdom: Gordon and Breach Publishers; 1996

[8] Karg S, Märkle T. Continuity and changes in plant resources during the Neolithic period in western Switzerland. Vegetation History and Archaeobotany. 2002;**11**:169-176

[9] Barros L et al. Strawberry-tree, blackthorn and rose fruits: Detailed characterization in nutrients and phytochemicals with antioxidant properties. Food Chemistry. 2010;**120**: 247-254

[10] Ayati Z et al. Phytochemistry, traditional uses and pharmacological profile of Rose Hip: A review. Current Pharmaceutical Design. 2018;**24**:1-24

[11] Dénes A et al. Wild plants used for food by Hungarian ethnic groups living in the Carpathian Basin. Acta Societatis Botanicorum Poloniae. 2012;**81**(4):381-396

[12] Hong L et al. Ethnobotany of wild plants used for starting fermented beverages in Shui communities of southwest China. Journal of Ethnobiology and Ethnomedicine. 2015;**11**:42

[13] Polumackanycz M et al. Phenolic composition and biological properties of wild and commercial Dog Rose fruits and leaves. Molecules. 2020;**25**:5272

[14] Günes M. Pomological and phenological characteristics of promising rose hip (Rosa) genotypes. African Journal of Biotechnology. 2010;**9**(38):6301-6306

[15] Al-Yafeai A et al. Characterization of carotenoids and vitamin E in *R. rugosa* and *R. canina*: Comparative analysis. Food Chemistry. 2018;**242**:435-442

[16] Phillips KM et al. Nutrient composition of selected traditional United States Northern Plains Native American plant foods. Journal of Food Composition and Analysis. 2014;**34**:136-152

[17] Ayati Z et al. Genus Rosa/ a review of ethnobotany, phytochemistry and traditional aspects according to Islamic Traditional Medicine (ITM). Advances

in Experimental Medicine and Biology. 2021;**1308**:353-401

[18] Polat R, Satıl F. An ethnobotanical survey of medicinal plants in Edremit Gulf (Balıkesir–Turkey). J Ethnopharmacol. 2012;**139**(2):626-641

[19] Ugulu I, Baslar S, Yorek N, Dogan Y. The investigation and quantitative ethnobotanical evaluation of medicinal plants used around Izmir province, Turkey. Journal of Medicinal Plants Research. 2009;**3**(5):345-367

[20] Pieroni A, Quave CL, Giusti ME, Papp N. "We are Italians!": The hybrid ethnobotany of a Venetian diaspora in Eastern Romania. Human Ecology. 2012;**40**(3):435-451

[21] Rivera D, Obon C, Inocencio C, et al. The ethnobotanical study of local Mediterranean food plants as medicinal resources in Southern Spain. Journal of Physiology and Pharmacology. 2005;**56**(1):97-114

[22] Arnold N et al. A contribution to the flora and ethnobotanical knowledge of Mount Hermon, Lebanon. Flora Mediterranea. 2015;**25**:13-55

[23] Winther K et al. Bioactive ingredients of rose hips (Rosa canina L.) with special reference to antioxidative and antiinflammatory properties: In vitro studies. Botanics: Targets and Therapy. 2016;**6**:11-23

[24] Olech M et al. Biological activity and composition of teas and tinctures prepared for Rosa rugosa Thunb. Central European Journal of Biology. 2012;**7**(1):172-182

[25] Olech M et al. Multidirectional characterization of chemical composition and health-promoting potential of *Rosa rugosa* hips. Natural Product Research. 2017;**31**(6):667-671

[26] Weidema I. NOBANIS—Invasive Alien Species Fact Sheet –*Rosa rugosa*. From: Online Database of the European Network on Invasive Alien Species. 2006: NOBANIS www.nobanis.org. Available from: https://www.nobanis.org/globalassets/speciesinfo/r/rosa-rugosa/rosarugosa.pdf [Accessed: April 2022]

[27] Skrypnik L et al. Evaluation of the rose hips of *Rosa canina* L and *Rosa rugosa* thunb. as a valuable source of biological active compounds and antioxidants on the Baltic Sea Coast. Polish Journal of Natural Sciences. 2019;**34**(3):395-413

[28] Engels G, Brinckmann J. Herbalgram: Dog rose hip Rosa Canina Family: Rosceaea. The Journal of the American Botanical Council. 2016;**111**:8-9

[29] Koczka N et al. Total polyphenol content and antioxidant capacity of rose hips of some Rosa species. Medicines. 2018;**5**:84

[30] Medveckiene B et al. The effect of ripening stages on the accumulation of carotenoids, polyphenols and vitamin C in rosehips species/cultivars. Applied Science. 2021;**11**:6761

[31] DTU Foods public food database. Rose hip. Food Database, version 4. 2019. Available from: https://frida.fooddata.dk/food/27langen

[32] Worrall S. A nightmare disease haunted ships during age of discovery. National Geographics. 2017. Available from: https://www.nationalgeographic.com/science/article/scurvy-disease-discovery-jonathan-lamb [Accessed: April 2022]

[33] Elste V et al. Emerging evidence on Neutrophil motility supporting its usefulness to define vitamin C intake requirements. Nutrients. 2017;**9**:503

[34] Pavek PLS. Plant guide for dog rose (*Rosa canina* L.). Pullman, WA: USDA-Natural Resources Conservation Service; 2012

[35] Nordic Council of Ministers. Nordic Nutrition Recommendation 2012, Integrating Nutrition and Physical Activity. Narayana Press, 2014. 5th edition

[36] Bozonet M et al. Enhanced human neutrophil vitamin C status, chemotaxis and oxidant generation following dietary supplementation with vitamin C-Rich SunGold Kiwifruit. Nutrients. 2015;**7**:2574-2588

[37] Levy R et al. Vitamin C for the treatment of recurrent furunculosis in patients with impaired neutrophil functions. The Journal of infectious diseases. 1996;**173**:1502-1505

[38] Covarrubias-Pinto A et al. Old things new view: Ascorbic acid protects the brain in neurodegenerative disorders. International Journal of Molecular Science. 2015;**16**:28194-28217

[39] Carr CA, Lykkesfeldt J. Discrepancies in global vitamin C recommendations: A review of RDA criteria and underlying health perspectives. Critical Reviews in Food Science and Nutrition. 2021;**61**(5) :742-755

[40] Lykkesfeldt J et al. Authors' perspective: What is the Optimum Intake of Vitamin C in Humans? Food Science and Nutrition. 2012;**2**:815-829

[41] Oprica L et al. Ascorbic acid content of rose hip fruits depending on altitude. Iranian Journal of Public Health. 2015;**44**(1):138-139

[42] National Institute for Health and Welfare. Rosehip, Rosa rugosa. Fineli Food Composition Database Release 19 (March 3, 2018), 2019. Available from: https://fineli.fi/fineli/en/elintarvik-keet/11007

[43] Al-Yafeai A et al. Bioactive compounds and antioxidant capacity of *Rosa rugosa* depending on degree of ripeness. Antioxidants. 2018;**7**:134

[44] Kazaz S et al. Variations in chemical compositions of Rosa damascena Mill. and *Rosa canina* L. fruits. Czech Journal of Food Science. 2009;**27**(3):178-184

[45] Demir F, Özcan M. Chemical and technological properties of rose (*Rosa canina* L.) fruits grown wild in Turkey. Journal of Food Engineering. 2001;**47**:333-336

[46] Mann J. Essentials of Human Nutrition. Oxford: Oxford University Press; 2017

[47] USDA, Food Data Central, SR legacy, released 2018. Acerola, (west Indian cherry), raw. Available from: https://fdc.nal.usda.gov/fdc-app.html#food-details/171686/nutrients

[48] Kaack K, Kuhn BF. Evaluation of rose hip species for processing of jam, jelly and soup. Tidsskr. Planteavl. 1991;**95**:353-358

[49] Przybylska S, Tokarczyk G. Lycopene in the prevention of Cardiovascular diseases. International Journal of Molecular Sciences. 2022;**23**:1957

[50] Mueller L, Boehm V. Antioxidant activity of beta-carotene compounds in different in vitro assays. Molecules. 2011;**16**:1055-1069

[51] Imran M et al. Lycopene as a natural antioxidant used to prevent human health disorders. Antioxidants. 2020;**9**:706

[52] Burton-Freeman BM, Sesso HD. Whole food versus supplement: Comparing the clinical evidence of tomato intake and lycopene supplementation on

cardiovascular risk factors. Advances in Nutrition. 2014;**5**:457-485

[53] Cheng HM et al. Tomato and lycopene supplementation and cardiovascular risk factors: A systematic review and meta-analysis. Atherosclerosis. 2017;**257**:100-108

[54] Böhm V et al. Rose hip—A new source of lycopene? Molecular Aspects of Medicine. 2003;**24**:385-389

[55] Carlsen MH et al. The total antioxidant content of more than 3100 foods, beverages, spices, herbs and supplements used worldwide. Nutrition Journal. 2010;**9**(3):1-11

[56] Carlsen HM, et al. The Antioxidant Food Table. 2010. Available from: http://www.Biomedcentral.com/content/supplementary/1475-2891-9-3-S1.pdf

[57] Institute of Physical Education and Nutrition. Radicals—what are free radicals (Danish). 2022. Copenhagen University. Available from: https://nexs.ku.dk/forskning/vidensbanken/radikaler/ [Accessed: April 15, 2022]

[58] Roman I, Stanila A, Stalina S. Bioactive compounds and antioxidant activity of *Rosa canina* L biotypes from spontaneous flora of Transylvania. Chemical Central Journal. 2013;**7**:73-85

[59] Kharazmi A, Winther K. Rose hip inhibits chemotaxis and chemiluminesence of human peripheral blood neutrophils in vitro and reduces certain inflammatory parameters in vivo. Inflammopharmacology. 1999;**7**(4):377-386

[60] Marstrand K, Warholm L, Pedersen F, Winther K. Dose dependent impact of rose-hip powder in patients suffering from osteoarthroitis of the hip and or knee—A Double Blind, Randomized, Placebo Controlled, Parallel Group, Phase III Study. International Journal of Complementary and Alternative Medicine. 2017;**7**(1):1-9

[61] Willich SN, Rossnagel K, Roll S, Wagner A, Mune O, Erlendson J, et al. Rose hip herbal remedy in patients with rheumatoid arthritis—A randomized controlled trial. Phytomedicine. 2010;**17**(2):87-93

[62] Winther K, Warholm L, Campbell-Tofte J, Marstrand K. Effect of *Rosa canina* L (Rose hip) on cold during winter season in a middleclass population: A randomized, double-blinded, placebo-controlled trial. Journal of Herbal Medicine. 2018;**43**:34-41

[63] Ginnerup-Nielsen E, Christensen R, Bliddal H, Zangger G, Hansen L, Henriksen M. Improved gait in persons with knee related mobility limitations by a rosehip food supplement: A randomized, double-blind, placebo-controlled trial. Gait and Posture. 2015; **42**(3):340-347

[64] Tiralongo E, Wee SS, Lea RA. Elderberry supplementation reduces cold duration and symptoms in air-travvellers: A Randomized, Double-blind, Placebo-Controlled Clinical Trial. Nutrients. 2016;**8**:182-197

[65] Lastra G, Sowers JR. Obesity and cardiovascular disease: Role of adipose tissue, inflammation, and the renin-angiotensin-aldosteron system. Hormone Molecular Biology and Clinical Investigation. 2013;**15**:49-57

[66] Anderson U, Berger K, Høgberg A, Landin-Olsson M, Holm C. Effects of rose hip intake on risk markers of type 2 diabetes and cardiovascular diseases: A randomized, double-blind, cross-over investigation in obese persons.

European Journal of Clinical Nutrition. 2012;**66**:585-590

[67] Rein E, Kharazmi A, Winther K. A herbal remedy, Hyben Vital (stand. Powder of a suibspecies of Rosa canina fruits), reduces pain and improves general wellbeing in patients with osteoarthrosis—A double-blind, placebo-controlled, randomized trial. Phytomedicine. 2004;**11**:383-391

[68] Cavalera M, Axling U, Rippe C, Swärd K, Holm C. Dietary rose hip exertrs antiatherosclerotic effects and increase nitric oxide-mediated dilatation in ApoE-null mice. The Journal of Nutritional Biochemistry. 2017;**44**:52-59

[69] Raiciu AD, Popescu M, Ivopol GC, Bordei N, Alexandru G, Crisan I, et al. Therapeutic applications of vegetable oils and GC-MS evaluation of omega 3, omega-6 and omega-9 amounts in six oleaginous plants. Review Chim. 2016;**67**:2449-2453

[70] Ninomiya K, Matsuda H, Kubo M, Morikawa T, Nishida N, Yoshikawa M. Potent anti-obese principle from *Rosa canina*: Structural requirements and mode of action of trans-tiliroside. Bioorganic and Medicinal Chemistry Letters. 2007;**17**:3059-3064

[71] Nagatomo A, Nishida N, Fukuhara I, Noro A, Kozai Y, Sato H, et al. Daily intake of rose hip extract decreases abdominal visceral fat in preobese subjects: A randomized, double-blind, placebo-controlled clinical trial. Diabetes Metabolism Syndrome Obesity. 2015;**8**:147

[72] Banfi G, Iorio EL, Corsi MM. Oxidative stress, free radicals and bone remodeling. Clinical Chemistry and Laboratory Medicine. 2008;**46**:1550-1555

[73] Scheweita S, Khoshhal K. Calcium metabolism and oxidative stress in bone fractures: Role of antioxidants. Current Drug Metabolism. 2007;**8**:519-525

[74] Devareddy L, Hooshmand S, Collins JK, Lucas EA, Chai SC, Arjmandi BH. Blueberry prevents bone loss in ovariectomized rat model of postmenopausal osteoporosis. Journal of Nutritional Biochemistry. 2008;**19**:694-699

[75] Halvorsen BL, Holte K, Myhrstad MCW, Barikmo I, Hvattum E, Remberg SF, et al. A systematic screening of total antioxidants in dietary plants. Journal of Nutrition. 2002;**132**:461-471

[76] Bernabei R, Mattone AM, Ortolani E, Lande F, Marzetti E. Screening, diagnosing and treatment of osteoporosis: A brief review. Clin Cases in Mineral and Bone Metabolism. 2014;**11**:201-207

[77] Fecka I. Qualitative and quantitative determination of hydrolysable tannins and other polophenols in herbal products from Meadowsweet and Dog Rose. Phytochemical Annal. 2009;**20**:177-190

[78] Hvattum E. Determination of Phenolic compounds in rose hip (*Rosa canina*) using liquid chromatography coupled to electrospray ionization tandem mass spectrometry and diode-array detection. Rapid Communication and Mass Spectrum. 2002;**16**:655-662

[79] Hubert PA, Lee SG, Chun OK. Dietary polyphenols, berries and are related bone loss: A review based on human, animal and cell studies. Antioxidants. 2014;**3**:144-158

[80] Phetcharat L, Wongsuphasawat K, Winther K. The effectiveness of a standardized rose hip powder, containing seeds and shells of Rosa canina, on cell longevity, skin wrinkles, moisture, and elasticity. Clinical Invervention in Aging. 2015;**10**:1-8

[81] Schwager J, Hoeller U, Wolframs S, Richard N. Rose hip and its constituents galactolipids confer cartilage protection by modulating cytokine and chemokine expression. BMC Complementary and Alternative Medicine. 2011;**11**:105

[82] Dieppe PA, Lohmander LS. Pathogenesis and management of pain in osteoarthritis. Lancet. 2005;**365**(9463): 965-973

[83] Vane JR, Botting RM. Anti-inflammatory drugs and their mechanisms of Action. Inflammation Research. 1998;**47**(2):78-87

[84] Griffin MR, Piper JM, Daugherty JR, Snowdon M, Roy WA. Non-steroidal anti-inflammatory drug use and increased risk for peptic ulcerdisease in elderly persons. Annals of Internal Medicine. 1991;**114**(4):257-263

[85] Silverstein JE, Faich G, Goldstein JL, Simon LS, Pincus T. Gastrintestinal toxicity with celecoxib vs nonsteroidal antiinflammatory drugs for osteoarthritis and rheumatoid arthritis. JAMA. 2000;**113**(25):1247-1255

[86] Gislason GH, Jacobsen S, Rasmussen JN, Rasmussen S, Buch P. Risk of death or reinfarction associated with the use of selective cyclooxygenase-2 inhibitors and nonselective nonsteroidal anti-inflammatory drugs after acute myocardial infarction. Circulation. 2006;**113**(25):2906-2913

[87] Roderigues G, Hernandes-Diaz S. Relative risk of upper gastrointestinal complications among users of acetaminophen and non-steroidal anti-inflammatory drugs. Epidemiology. 2001;**12**(5):570-576

[88] Warholm O, Skaar S, Hedman E, Mølmen HM, Eik L. Placebo-Controlled Clinical Trial. Current Therapeutyic Research. 2003;**64**(1):21-31

[89] Winther K, Apel K, Thamsborg G. A powder made from seeds and shells of a rose-hip subspecies (*Rosa canina*) reduces symptoms of knee and hip osteoarthritis: A randomized, double-blind, placebo-controlled clinical trial. Scandinavian Journal of Rheumatology. 2005;**34**:302-308

[90] Winther K, Campbell-Tofte J, Hansen P. Rose Hip Powder that contains the natural amount of shells and seeds alleviate pain in osteoarthritis of the dominant hand—Ramdomized, Double-Blind, Placebo-Controlled, Cross-over Clinical Trial. Open Journal of Rheumatology and Autoimmune Diseases. 2013;**3**:172-130

[91] Christensen R, Bartels EM, Altman RD, Astrup A, Bliddal H. Does the hip powder of Rosa canina (rosehip) reduce pain in osteoarthritis patients?—A meta-analysis of randomized controlled triasls. Osteoarthritis and Cartillage. 2008;**16**:965-972

[92] Verkleij SPJ, Luijsterburg PAJ, BohnenAM,KoesBW,Bierma-ZeinstraSMA. NSAIDs vs acetaminophen in knee and hip osteoarthritis: A systematic review regarding hetyerogeity influencing the outcomes. Osteoarthrosis and Cartilage. 2011;**19**:921-929

[93] Pelletier J-P, Martel-Pelletier J, Rannou F, Cooper C. Efficacy and safety of Oral NSAIDs and analgesics in the management of osteoarthritis: Evidence from real-life setting trials and surveys. Seminars in Arthritis and Rheumatism. 2016;**45**:22-27

[94] Kirkeskov B, Christensen R, Bügel S, Bliddal H, Danneskiold-Samsøe B, Christensen LP, et al. The effects of rose hip (Rosa canina) on plasma antioxidative activity and C-reactive protein in patients with rheumatoid arthritis and normal

controls: A prospective cohort study. Phytomedicine. 2011;**18**:953-958

[95] Larsen E, Kharazmi A, Christensen LP, Christensen SB. An anti-inflammatory galactolipid from Rose hip (*Rosa canina*) that inhibits chemotaxis of human peripheral blood neutrophils in vitro. Journal of Natural Production. 2003;**66**:994-995

[96] Winther K, Kharazmi A, Hansen ASV, Falk-Rønne J. The absorption of natural vitamin C in horses and anti-oxidative capacity: A randomized, controlled study on trotters during a three month intervention period. Comparative Exercise Physiology. 2012;**8**(3/4):195-201

[97] Jäger AK, Petersen KN, Thomasen G, Christensen SB. Isolation of linoleic and alpha-linolenic acids as COX-1 and COX-2 inhibitors in rose hip. Phytotherapy Research. 2008;**22**:982-984

[98] Saaby L, Jäger AK, Moseby L, Hansen EW, Christensen SB. Isolation of immunomodulatory Triterpene Acids from a Staqndardized Rose Hip Powder (*Rosa canina* L). Phytotherapy Research. 2011;**25**:195-201

[99] Ashtiyani SC, Najafi H, Jalalvandi S, Hosseinei F. Protective effect of the total flavonoids from *Rosa canina* L fruit extracts on renal disturbances induced by reperfusion injury in rats. Iraniam Journal of Kidney Diseases. 2013;**7**:290

[100] Zhao L, Xu L, Tao X, Han X, Yin L, Qi Y, et al. Protective effect of the total flavonoids form Rosa Laevigata michx fruit on renal ischaemia-reperfusion injury through suppression of Oxidative stress and inflammation. Molecules. 2016;**21**:952

[101] Kashihara M, Haruna Y, Kondeti K, Kanwar Y. Oxidative stress in diabetic nephropathy. Curr Med Chem. 2010;**17**: 4256-4269

[102] Zhou Y, Liao Q, Luo Y, Qing Z, Zhang Q, He G. Renal protective effect of Rosa Laevigata michx. By the inhibition of oxidative stress in streptozotocin-induced diabetic rats. Molecular Medicine Reports. 2012;**5**:1548-1554

[103] Tayefi-Nasrabadi H, Sadigh-Eteghad S, Aghdam Z. The effect of the hydroalcoholic extract of *Rosa canina* L Fruits on experimentally nephrolithisic whistar rats. Phytotherapy Research. 2012;**26**:78-85

[104] Sadeghi H, Hosseinzadeh S, Touri MA, Ghavamzadeh M, Barnak MJ. Hepatoprotective effect of Rosa canina fruit extract against carbon tetrachloride induced hepatoxicity in rat. Avicenna Journal of Phytomedicine. 2016;**6**:181

[105] Liu L, Yasen M, Tang D, Ye J, Aisa A, Xin X. Polyphenol-enriched extract of *Rosa rogusa* Thumb regulates lipid metabolism in diabetic rats by activation of AMPK parthway. Biomed and Pharmacother. 2018;**100**:29-35

[106] Rittie L, Fisher GJ. Natural and sun-induced aging of human skin. Cold Springer and Harbor Perspective Medicine. 2015;**5**:a015370

[107] Wang D, Beck LA. Immunologic targets in atopic dermatitis and emerging therapies: An update. American Journal of Clinical Dermatology. 2016;**17**:425-443

[108] Parl KH, Jeong MS, Park KJ, Choi YW, Seo SJ, Lee MW. Topical application of Rosa multiflora root extract improves atopic dermatitis-like skin lesions induced by mite antigen in NC/NGA mice. Biological Pharm Bulletin. 2014;**37**:178-183

[109] Pillaiyar T, Manickam M, Namasivayam V. Skin whitening agent: Medical chemistry perspectives of tyrosinhase inhibitors. Journal of

Enzyme Inhibition and Medicinal Chemistry. 2017;**32**:403-425

[110] Fujii T, Ikeda K, Saito M. Inhibitory effects of rose hip (*Rosa canina* L) on melanogenesis in mouse melanoma cells and on pigmentation in brown guinea pigs. Bioscience, Biotechnology, and Biochemistry. 2011;**75**:489-495

[111] Wertz PW. Epidermal lipids. Seminars in Dermatology. 1992;**11**: 106-113

[112] Öscan M. Nutrient composition of Rosa canina L. Seed and oils. Journal of Medicinal Food. 2002;**5**(3):137-140

[113] Gürbüz I, Üstün O, Yesilada E, Sezik E, Kutsal O. Antiulcerogenic activity of some plants used as folk remedy in Turkey. Journal of Ethnopharmacy. 2003;**88**:93-97

[114] Rao A, Gurfinkel D. The Bioactivity of saponins: Triterpenoid and steroidal glycosides. Drug Metabolism and Drug Interact. 2000;**17**:211-236

[115] Meli R, Di Carlo G, Capasso F. Inhibitory action of quercetin on essential transit in mice. Phytotherapy Research. 1990;**4**:201-202

[116] Bütner S, Jacobsen O, Andersen JR, Winther K. The Impact of a astandardized powder made from a subtype of Rose-hip on IBDQ symptom score in patients with Chrons`s Disease or Ulcerative Cholitis. Scandinavian Journal of Gastroenterology. 2004;**39**(240):39

[117] Tumbas VT, Canadanovic-Brunet JM, Cetojevic DD, Cetkovic GS. Effect of rosehip (*Rosa canina* L) phytochemicals on stable free radicals and human cancer cells. Journal of Science Food and Agriculture. 2012;**92**(6):1273-1281

[118] Jemenez S, Gascon S, Luquin A, Laguna M, Ancin-Azpilicueta C, Rodriquez-Yoldi MJ. Rosa canina extracts have antiproliferative and antioxidant effects on Caco-2 human colon cancer. Plos One. 2016;11(7):e0159136. DOI: 10.1371/journal.pone.0159136

[119] Kilinc K, Demir S, Turan I, Mentese A, Orem A, Sonmez M. Rosa canina extract has antiproliferative and proapoptotic effects on human lung and prostate cancer cells. Nutrition and Cancer. 2019;**72**(2):273-282